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EVALUATION OF NIGHT VISION GOGGLES FOR MARITIME SEARCH AND RESCUE

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INTERIM REPORT

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NOTICE

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This report is the second in a series that will document the Improvement of Search and Rescue Capabilities (ISARC) Project at the U.S.C.G. R&D Center and twenty-eighth in a series of R&D Center reports dealing with Search and Rescue.

16. Abstract

Three experiments were conducted during 1989 and a fourth was conducted in the spring of 1990 by the U.S. Coast Guard Research and Development (R&D) Center to evaluate night vision goggles (NVGs) for their effectiveness in detecting small targets at night. Three types of NVGs were evaluated: the AN/AVS-6 Aviators Night Vision Imaging System (ANVIS) NVG was tested onboard Coast Guard HH-3 and CH-3 helicopters, and the AN/PVS-5C and AN/PVS-7A NVGs were tested onboard 41-foot Coast Guard utility boats (UTBs). During the spring 1990 experiments, simulated persons in the water (PIWs) wearing orange personal floatation devices (PFDs), retroreflective tape, and either a green personnel marker light (PML) or a red safety light; 4- and 6-person life rafts with and without retroreflective tape; and 18- and 21-foot white boats were employed as targets during realistically-simulated search missions and are discussed herein. This second interim report will discuss new information obtained from the spring 1990 data.

A total of 1,355 target detection opportunities were generated for the above-mentioned target types during the four experiments. These data were analyzed to determine which of 25 search parameters of interest exerted a statistically-significant influence on target detection probability. Lateral range curves and sweep width estimates are developed for each search unit/target type combination. Human factors data are presented and discussed. Recommendations for conducting NVG searches for small targets and for additional data collection and analysis are provided.

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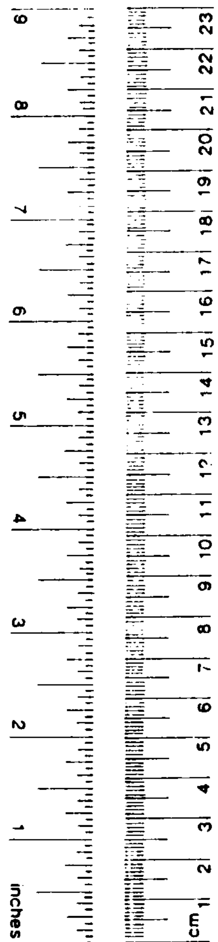
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25, SD Catalog No. C13 10.286



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

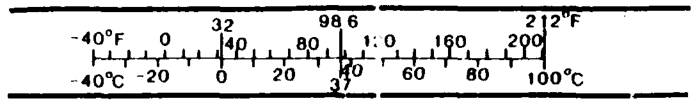


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TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

LIST OF ILLUSTRATIONS

LIST OF TABLES

EXECUTIVE SUMMARY

INTRODUCTION

1. Background

This report provides a second interim evaluation of three types of night vision goggles (NVGs) for their effectiveness in the Coast Guard's maritime search and rescue (SAR) mission. The NVGs were evaluated onboard HH-3 and CH-3 helicopters from Coast Guard Air Stations Traverse City, MI, and Cape Cod, MA, and on 41-foot utility boats (UTBs) from Coast Guard Stations Fort Pierce, FL, New London, CT, Point Judith, RI, and Montauk, NY. Data were collected during a 3-week experiment in Fort Pierce, FL in April 1989, during two, 3-week experiments conducted in Block Island Sound (off the CT/RI/NY coasts) during the fall of 1989, and during a 3-week experiment in Fort Pierce, FL in March 1990. This report will update analyses of NVG detection performance based on data that were obtained during the April 1990 experiment. Target types evaluated in this report include simulated persons in the water (PIWs) with orange personal floatation devices (PFDs), retroreflective tape, and either green Cyalume personnel marker lights (PMLs) or red Cyalume Safety Lights; 4- and 6-person life rafts with orange canopies with or without retroreflective tape; white, 18-foot open boats; and white, 21-foot boats with blue canvas bow shelters and bimini tops.

These evaluations were conducted by the U.S. Coast Guard Research and Development (R&D) Center as part of the Improvement of Search and Rescue Capabilities (ISARC) Project. This research is ongoing, with additional experiments and data analyses planned for calender years 1990 and 1991.

2. NVG Descriptions

Three NVG models were evaluated during the experiments onboard two types of search and rescue units (SRUs). The AN/AVS-6 Aviators Night Vision Imaging System (ANVIS) NVGs, equipped with Generation III photodetectors, were evaluated onboard the helicopters. All five

helicopter crew positions were provided with ANVIS NVGs on hinged helmet mounts. UTB crews were provided with either AN/PVS-5C or AN/PVS-7A NVGs for use by lookouts only. The AN/PVS-5C and AN/PVS-7A are both equipped with Generation II-plus photodetectors and fixed headstrap mounts. Helmsmen and coxswains positioned inside the UTB wheelhouse were unable to operate with these NVGs due to the lack of NVG-compatible instruments and radar displays.

All three NVG models restrict visual perception in several ways. All models restrict the users to a 40-degree field of view, severely inhibit depth perception, reduce visual acuity to 20/40 at best, and provide a monochromatic (green) display. The ANVIS and the AN/PVS-7A designs allow limited, non-NVG peripheral vision. The AN/PVS-5C design does not permit any peripheral vision.

3. Approach

Data were collected using operational Coast Guard search craft and crews that had received basic instruction in NVG use. Standard search patterns were used to search for randomly-placed targets within assigned search areas. Search crews were not alerted to target locations in advance.

A precision microwave tracking system was used to monitor and record target and search craft positions. Target detections and human-factors data were logged by data recorders onboard each search unit. Environmental data were logged onboard a chartered work boat. An environmental data buoy was deployed within each exercise area to record winds, sea conditions, and air/water temperatures.

Data reconstruction was performed to determine which target opportunities resulted in detection and at what lateral range each opportunity occurred. Raw data files were developed that included each target detection or miss along with the values of 25 search parameters of interest for each target opportunity. These data were analyzed on a desktop computer using a variety of statistical techniques including binary, multivariate regression analysis. Lateral range versus target detection probability plots and sweep width estimates were developed for search conditions that were well-represented in the data.

Human factors data were compiled and analyzed quantitatively where possible. Subjective comments by search unit crews and data recorders were synopsized and incorporated into the conclusions and recommendations provided in this report.

RESULTS AND CONCLUSIONS

1. Results

A total of 1,355 detection opportunities were reconstructed from the four experiments for the target types discussed in this report. Table 1 provides a breakdown of data quantities categorized by search unit and target type. Of the nine search unit/target type combinations evaluated during the April 1990 experiment, sufficient new data were collected to perform a detailed detection performance analysis on only those five denoted with an asterisk (*) in table 1. During the April 1990 experiment, data were collected for the first time on life rafts with retroreflective tape, PIWs with red Safety Lights, and PIWs with green PMLs.

Table 1. Numbers of Target Detection Opportunities by SRU and Target Type

TARGET TYPE	SRU TYPE	
	Helicopter	UTB
18- and 21-foot Boats	332*	131
4- and 6-person Life Rafts without Retroreflective Tape	282*	198*
4- and 6-person Life Rafts with Retroreflective Tape	55*	10
PIWs with Red Safety Light	232*	25
PIWs with Green Personnel Marker Light	90	No data collected

* to be analyzed in detail in this report

Table 2 summarizes the range of search conditions represented in the data set. New or updated lateral range curve plots and sweep width (W) estimates were developed for the following conditions.

a. Helicopter/PIW Targets with Red Safety Light. Three sets of search conditions described below.

(1) Moon visible, all artificial light relative azimuths.

(2) Moon not visible, looking toward the dominant source of artificial light.

(3) Moon not visible, looking across or away from the dominant source of artificial light.

b. Helicopter/Life Raft Targets without Retroreflective Tape. Two sets of search conditions described below.

(1) Moon visible.

(2) Moon not visible.

c. Helicopter/Life Raft Targets with Retroreflective Tape. All data combined.

d. Helicopter/Small Boat Targets. Three sets of search conditions described below.

(1) Significant wave height (H_S) 2.0 to 3.3 feet, visibility 6 to 15 nmi, and a visible moon.

(2) H_S 2.3 to 3.3 feet, visibility 6 to 15 nmi, and moon not visible.

e. UTB/Life Raft Targets without Retroreflective Tape. Two sets of search conditions described below.

(1) Moon visible.

(2) Moon not visible.

Table 2. Range of Environmental and Moon Parameters Encountered

SRU/ TARGET	ENVIRONMENTAL PARAMETERS									MOON	
	Precipitation Level	Visibility (nmi)	Wind Speed (knots)	Cloud Cover (tenths)	Significant Wave Height (ft)	Whitecap Coverage	Relative Humidity (percent)	Air Temperature (deg. C)	Water Temperature (deg. C)	Elevation (degrees)	Phase
Helo/Boats	0 to 1	1.5 to 15	1.6 to 20	0 to 1	1.3 to 4.3	0 to 2	61 to 96	10.4 to 24.3	13.4 to 24.2	-68 to 65	none to full
Helo/PIW w/Red Safety Lights	0 to 3	15 to 15	5 to 15	.1 to .9	2 to 4.3	0 to 1	61 to 8[illegible]	22.2 to 26	22 to 24	-67 to 19	quarter to 3 quarter
Helo/PIW w/Personnel Marker Light	0 to 0	15 to 15	5 to 10	.2 to .4	5.2 to 6.2	0 to 0	63 to 69	21.1 to 21.5	20.8 to 22.2	47 to 57	full
Helo/Rafts w/Retroreflective Tape	0 to 0	15 to 15	8 to 16	0 to .4	3.0 to 4.3	0 to 0	60 to 71	21.7 to 23.0	21.8 to 22.5	-66 to 22	quarter to full
Helo/Rafts Without Retroreflective Tape	0 to 3	1.5 to 15	3 to 16	0 to .1	1.6 to 5.2	0 to 2	61 to 100	10.4 to 24.3	13.4 to 23.0	-69 to 69	none to full
UTB/ Boats	0 to 1	1.5 to 15	1.6 to 20	0 to 10	1.3 to 4.3	0 to 2	61 to 96	5.5 to 24.3	13.4 to 24.2	-60 to 51	none to full
UTB/PIW w/Red Safety Lights	0 to 3	15 to 15	5 to 15	.3 to .9	2 to 3.6	0 to 1	74 to 78	23.3 to 26	23.5 to 24	-64 to 6	quarter to 3 quarter
UTB/Rafts w/Retroreflective Tape	0 to 0	15 to 15	7 to 16	.1 to .4	3.5 to 4.3	0 to 2	60 to 71	21.6 to 23.9	21.4 to 22.1	-63 to 38	quarter to full
UTB/Rafts Without Retroreflective Tape	0 to 2	1.5 to 15	2 to 24	0 to 1.0	1.3 to 4.6	0 to 2	61 to 100	6.1 to 24	13.5 to 23.6	-62 to 52	none to full

Data sets for other SRU/target type combinations and search conditions were either not large enough to analyze in-depth or had not changed sufficiently to warrant an updated analysis. Raw data plots only were developed for helicopters searching for PIWs with green PMLs, UTBs searching for rafts with retroreflective tape, and UTBs searching for PIWs with red Safety Lights.

An updated analysis of detections by crew position confirmed the following trends which were reported earlier.

a. The copilot position (left seat) made more detections than the pilot position (right seat) for all data sets. This difference is consistent across all target types, and suggests a degradation in search capability that results from constant scan-shifting by the pilot between NVGs outside the cockpit and unaided vision inside the cockpit even while not actually flying the aircraft.

b. In the aft section of the helicopter, the flight engineer, who usually searches through an open door with a wide field of view and no glass to reflect light, made more detections overall than either the rescue swimmer position or the avionics position.

c. Evaluation of the composite UTB data indicates that the starboard aft lookouts made more detections than the port aft lookouts. This may be because the cabin door is directly adjacent to the port aft lookout position. The open door may have allowed more light to interfere with NVG operation and more distraction of the port aft lookout due to conversations with personnel inside the wheelhouse.

2. Conclusions

1. Green PMLs do not appear to enhance the detectability of PIW targets when viewed through ANVIS goggles.

2. When the moon is not visible, red Safety Lights significantly enhance the detectability of PIWs when viewed through ANVIS goggles. When the moon was visible, detection performance was comparable to levels achieved for PIW targets with retroreflective tape alone.

3. When the moon is not visible, looking toward moderate levels of artificial light through the ANVIS goggles appears to diminish the detectability of red Safety Lights by about 25 percent.

4. The presence of a visible moon appears to double ANVIS detection performance against life raft targets without retroreflective tape.

5. Analysis of limited data indicates that the addition of retroreflective tape to life rafts in accordance with Safety of Life At Sea (SOLAS) specifications may at least double their detectability by the ANVIS goggles.

6. Additional data collected in 1990 indicate that moonlight exerts a somewhat stronger influence on the detectability of white, 18- to 21-foot boats than previously reported.

7. Based on a very limited data set, it appears that UTBs achieve only marginal detection performance against red Safety Lights at lateral ranges less than 0.5 nmi. No detections were achieved at lateral ranges greater than 0.5 nmi.

8. The presence of a visible moon appears to significantly enhance UTB detection performance against life rafts without retroreflective tape.

9. The presence of a visible moon significantly enhances the ability of NVG-equipped SRUs to detect small search targets that are not equipped with lights.

10. The presence of moonlight or artificial light in the background against which a light-equipped target is viewed will likely diminish the detectability of that target by NVGs.

RECOMMENDATIONS

The following interim recommendations are added to those reported previously. These recommendations are based on new information obtained during the spring 1990 NVG test.

Daylight visual sweep widths referenced below are tabulated in the National Search and Rescue Manual (SAR Manual). Fatigue, weather, and speed corrections listed in the SAR Manual are not to be applied unless specified below.

1. NVG Searches With Helicopters

a. For search planning purposes, PIWs with green PMLs should be treated the same as PIWs without lights when computing sweep width.

b. If a PIW is known to be equipped with a functioning red chemical Safety Light, the following sweep width estimates should be used.

moon visible in search area - use the daylight visual sweep width for PFD-equipped PIWs and search altitudes up to 500 feet. This value is currently 0.4 nmi.

moon not visible in search area - multiply the daylight visual sweep width specified above by 2.5.

c. The following sweep width estimates should be used when the search object is a 4- or 6-person life raft without retroreflective tape.

moon visible in search area - multiply the daylight visual sweep width, corrected for weather only, by 0.35.

moon not visible in search area - multiply the daylight visual sweep width, corrected for weather only, by 0.2.

d. Pending additional data collection, sweep width for 4- or 6-person life rafts with retroreflective tape applied per SOLAS specifications should be estimated by multiplying the daylight visual sweep width, corrected for weather only, by 0.9.

e. Guidance provided earlier for estimating sweep width for small boat targets is still valid.

2. NVG Searches With UTBs

a. The following guidelines should be used when estimating sweep width for life raft targets without retroreflective tape.

moon visible in search area - multiply the daylight visual sweep width, corrected for weather only, by 0.3.

moon not visible in search area - NVG search by UTBs is not recommended under these conditions.

b. No search planning guidance applicable to UTBs searching for red Safety Lights or 4- and 6- person life rafts with retroreflective tape can be made until additional data are collected.

3. General Recommendation

When the search object is known to be equipped with a light, search planners should assign NVG search patterns with major legs oriented perpendicular to shore lights if the shore lights are likely to be visible from the SRU.

4. Recommendations For Future Research

a. More NVG search performance data should be collected in moonlit conditions. Data for clear, calm moonlit conditions are especially lacking in the existing NVG data base.

b. Data collection priorities for future NVG tests are listed below in descending order of preference.

- 18- and 21-foot boats in moonlit conditions,
- PIW targets without lights in moonlit conditions,
- raft targets without retroreflective tape in moonlit conditions,
- raft targets with retroreflective tape in all search conditions, and
- red Safety Lights in moonlit conditions (helicopter) or all conditions (UTB).

c. Larger surface SRUs (such as WPBs and WMECs) should be evaluated for their NVG search performance.

d. UTBs should be evaluated using four NVG lookouts on a 2-on/2-off rotation to alleviate fatigue and seasickness.

e. Sources of NVG-compatible illumination should be evaluated on surface and air SRUs, particularly against targets that are not equipped with lights. These targets should include both retroreflective and non-retroreflective materials.

f. The HH-65A and HH-60J Coast Guard helicopters should be evaluated for their NVG search performance. Since the HH-65A and HH-60J carry smaller crews than the HH-3 and CH-3 helicopters used for this study, it is possible that their NVG detection performance will not be as good as that reported here.

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We also extend our appreciation for the services provided by Mr. A. Allen in preparation and deployment services for the environmental buoys and for his oversight of surface operations; Mr. M. Couturier and Mr. D. Brennen for Command and Control operations during the field tests; Mr. G. Reas for his expertise in servicing and maintaining the electrical equipment and the night vision goggles; Mr. S. Ricard, Mr. R. Marsee, and Mr. T. Noble who provided field and target support and also for their assistance in data collection and analysis.

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CHAPTER 1
INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This report is the second of a series that will document the U.S. Coast Guard Research and Development (R&D) Center's evaluation of night vision goggles (NVGs) and other night vision devices for search and rescue (SAR) missions. To date, four experiments have been conducted in support of this evaluation. During 1989, one experiment was conducted in Fort Pierce, FL and two experiments were conducted in Block Island Sound off the CT/RI/NY coasts. Reference 1 presented an analysis of data collected during the first three experiments. This report will present updated analyses of NVG detection performance using the additional data from an experiment conducted in Fort Pierce, FL during March 1990. During these experiments, three types of NVGs have been evaluated onboard HH- and CH-3 helicopters and 41-foot utility boats (UTBs) for their effectiveness in detecting person-in-water (PIW), life raft, and small boat targets. Data for target types that were deployed for the March 1990 experiment have been combined with previous data where applicable. Data for three new target types are also analyzed in this report. Additional experiments and data analyses are planned for fall 1990 and winter/spring 1991.

This evaluation of night vision devices is part of the R&D Center's Improvement of Search and Rescue Capabilities (ISARC) Project. Project objectives are to improve search planning and execution and to evaluate visual and electronic search methods, leeway drift, ocean current drift, and visual distress signals. Specific objectives of the night vision device evaluations are to:

1. Establish the night SAR capabilities of operational Coast Guard search and rescue units (SRUs) equipped with these devices, and

2. Develop operationally-realistic sweep widths that search planners can use to represent Coast Guard night search effectiveness under a variety of environmental and lighting conditions.

1.2 NIGHT VISION GOGGLE SYSTEM DESCRIPTIONS

The AN/AVS-6 Aviator's Night Vision Imaging System (ANVIS) was evaluated onboard Coast Guard HH-3F and CH-3E helicopters. The AN/PVS-5C and AN/PVS-7A NVGs were evaluated onboard Coast Guard 41-foot UTBs. All three NVG models amplify available light to produce a monochromatic (green) image of the nighttime scene. As ambient light level varies, NVG image quality varies: Too much or too little light can cause poor image quality. All of the NVG systems evaluated severely inhibit depth perception and reduce visual acuity to no better than 20/40. Sections 1.2.1 and 1.2.2 describe specific features of the three NVG systems.

1.2.1 AN/AVS-6 ANVIS

The ANVIS goggles shown in figure 1-1 are a helmet-mounted NVG system designed for use by helicopter crews operating in a broad range of night illumination conditions including starlight and overcast. Two Generation III image intensifier tubes are incorporated into a hinged, binocular assembly that can easily be flipped up or down by the aviator. Adjustments for diopter correction, range focus, interpupillary separation, vertical positioning, fore-aft positioning (eye relief), and tilt positioning are also incorporated into the ANVIS goggles.

When in use (down position), the binocular assembly is offset from the eyes so that limited non-NVG peripheral vision is available. The eyes may also be focused beneath the goggles to view instruments and controls. The ANVIS goggles provide a 40-degree field of view (FOV). Peak spectral response is achieved with the ANVIS between wavelengths of 0.65 and 0.90 microns, which includes visible light from green through red and a portion of the near-infrared spectrum. A "minus blue" instrument light filter that eliminates wavelengths smaller than 0.625 microns (yellow) is incorporated into the ANVIS. An automatic brightness control adjusts rapidly to changing illumination conditions.

The ANVIS goggles tested during the three R&D Center experiments were manufactured by ITT Electro-Optics Division, Litton Electron Devices, and Varian Corporation. Detailed ANVIS specifications and principals of operation can be found in references 2 and 3.

Figure 1-1. AN/AVS-6 ANVIS Night Vision Goggles

1.2.2 AN/PVS-5C and AN/PVS-7A NVGs

The AN/PVS-5C and AN/PVS-7A/NVGs shown in figures 1-2 and 1-3, respectively, are infantry-type NVGs designed to be worn with fixed headstrap mounts. The AN/PVS-5C goggles tested were Litton Model M-915A, incorporating 2 Generation II-plus image intensifier tubes and an available short-range infrared illuminator (not evaluated). The AN/PVS-7A goggles tested were Litton model M-972, incorporating a single Generation II-plus image intensifier, a short-range infrared illuminator (not evaluated), and a binocular lens assembly. Adjustments for diopter correction, range focus, interpupillary separation, tilt positioning and fore-aft (eye relief) positioning are incorporated into both of these NVG models. The headstrap assemblies for both models adjust to fit the individuai wearer.

When used with the headstrap assemblies, peripheral vision is unavailable with the AN/PVS-5C and restricted with the AN/PVS-7A. Both NVG models provide a 40-degree FOV. Peak response is in the visible portion of the spectrum, with reduced amplification in the near-infrared to 0.86-micron wavelengths. Automatic brightness control is provided in both NVG models.

The AN/PVS-5C and AN/PVS-7A NVGs tested during the three R&D Center experiments were all manufactured by Litton Electron Devices. Detailed specifications can be found in references 4 and 5.

1.3 EXPERIMENT DESCRIPTIONS

A total of four experiments have been conducted to date in support of the NVG evaluation effort. From 17 April to 6 May 1989, a 3-week experiment was conducted off Fort Pierce, FL. Reference 6 documents the "quick-look" results summary from this test. From 18 September to 7 October and again from 23 October to 11 November 1989, two additional experiments were conducted in Block Island Sound off the CT/RI/NY coasts. Reference 7 documents the "quick look" results from the two Block Island Sound tests. From 5 March to 23 March 1990 an additional 3-week experiment was conducted off Fort Pierce, FL. Reference 8 documents the "quick-look" results summary from the March 1990 test. Sections 1.3.1 through 1.3.6 provide detailed information concerning the four experiments.

Figure 1-2. AN/PVS-5C Night Vision Goggles

Figure 1-3. AN/PVS-7A Night Vision Goggles

1.3.1 Participants

The NVG experiments were controlled by the Oceanography Branch of the Coast Guard R&D Center, Avery Point, Groton, CT. R&D Center personnel assisted by contractor computer programmers and technicians erected, operated, and maintained a precision microwave tracking system (MTS) and a radio-equipped control center at each experiment site. The R&D Center Project and Test Managers arranged for primary logistics support to these facilities, handled liaison among all Coast Guard and contractor participants, and maintained top-level control of all experiment communications and data collection activities.

The prime contractor was Analysis & Technology Inc. (A&T). A&T prepared test plans, installed MTS equipment and provided data recorders onboard participating SRUs, procured and maintained target craft, and provided a chartered workboat at each site to deploy and recover an environmental data buoy and target craft.

1.3.1.1 Florida Experiment, April 1989

During the first Florida experiment a Coast Guard HH-3F helicopter (CG 1469) from Air Station Traverse City, MI was provided on-site at St. Lucie County Airport with a seven-person crew. Pilots were rotated midway through the 3-week test period while the five-man aircrew remained for the entire period with three flying on any particular night. Coast Guard Air Station Clearwater, FL provided limited maintenance and logistics support to the Traverse City aircraft and crew during its deployment.

Coast Guard Station Fort Pierce, FL scheduled a 41-foot UTB (CG 41461) and crew for each night using its normal complement of personnel. Station Fort Pierce also provided dockage for the chartered workboat, provided staging area and dockspace for target craft, and assisted A&T personnel with the handling of target craft. Experiment-related message traffic was passed to and from the R&D Center Test Manager via the Station Fort Pierce communications center.

A 95-foot workboat, the R/V OSPREY, was chartered by A&T from the Florida Institute of Technology (FIT) to provide on-scene support to the Florida experiment. The R/V OSPREY deployed and retrieved the instrumented environmental data buoy in the Fort Pierce exercise area. The R/V OSPREY also deployed and retrieved all target craft used during data collection and provided backup weather observations each night.

1.3.1.2 Block Island Sound Experiments, Fall 1989

During both Block Island Sound experiments Coast Guard Air Station Traverse City, MI provided a CH-3E helicopter on-site at Groton-New London Airport and a seven-person crew to support data collection. During the first experiment, aircraft number CG 9691 was provided with a complete aircrew change midway through the 3-week period. During the second experiment, aircraft number CG 2793 was provided with a complete aircrew change midway through the experiment. Coast Guard Air Station Cape Cod, MA provided limited logistics support to the Traverse City crews during these deployments.

Coast Guard Stations Montauk, NY, New London, CT, and Point Judith, RI were each scheduled to provide a 41-foot UTB nightly to support Block Island Sound data collection. Vessels that participated on one or more nights are listed below.

Unit	Vessel(s)
CG Station Montauk, NY	CG 41342
CG Station New London, CT	CG 41337, CG 41350
CG Station Point Judith, RI	CG 41385

Experiment-related message traffic was handled directly through the R&D Center in Groton, CT and a tenant command, the International Ice Patrol.

A 65-foot workboat, the R/V UCONN, was chartered by A&T from the University of Connecticut's Marine Sciences Institute to provide on-scene support to the two Block Island Sound experiments. The R/V UCONN deployed the environmental data buoy, handled all target deployments/retrievals and obtained backup weather observations. The environmental data buoy was recovered by the F/V QURANBAUG QUEEN under a direct charter from the R&D Center.

1.3.1.3 Florida Experiment, March 1990

During this Florida experiment a Coast Guard HH-3F helicopter (CG 1488) from Air Station Cape Cod, MA was provided on-site at St. Lucie County Airport with a seven-person crew. Aircrews were rotated midway through the 3-week test period. Coast Guard Air Station

Coast Guard Station Fort Pierce, FL scheduled a 41-foot UTB (CG 41341) and crew for each night using its normal complement of personnel. Station Fort Pierce also provided dockage for the chartered workboat, provided staging area and dockspace for target craft, and assisted A&T personnel with the handling of target craft. Experiment-related message traffic was passed to and from the R&D Center Test Manager via the Station Fort Pierce communications center.

A 95-foot workboat, the R/V OSPREY, was chartered by A&T from FIT to provide on-scene support to the Florida experiment. The R/V OSPREY deployed and retrieved the instrumented environmental data buoy in the Fort Pierce exercise area. The R/V OSPREY also deployed and retrieved target craft used during data collection and provided backup weather observations.

1.3.2 Exercise Areas

The primary exercise area for the Fort Pierce experiment was a 10- by 20- nmi area centered at 27°32.6'N, 80°09.0'W along a major axis of 160 degrees magnetic. Figure 1-4 depicts the Fort Pierce exercise area and indicates the locations of land-based MTS components. SRUs were assigned specific search patterns within this area, which varied in size from 4 by 8 nmi to 10 by 12 nmi, depending on target and SRU type.

In Block Island Sound, search patterns ranging in size from 4 by 5 nmi to 8 by 12 nmi were assigned in various parts of the exercise area according to target type, SRU type and prevailing winds/seas. Figure 1-5 depicts the Block Island Sound exercise area and indicates the locations of land-based MTS components.

In both exercise areas, an operations center was established at the MTS master station location and equipped with all computer and communications equipment required to direct data collection activities and record target and SRU position information. This facility, known as R&D Control, was located at the Sea Palms Condominiums in Fort Pierce during the spring 1989 experiment; at Watch Hill Light on Block Island Sound during the fall 1989 experiments; and at the Tiara North Condominiums in Fort Pierce during the spring 1990 experiment. These locations are depicted in figures 1-4 and 1-5, respectively.

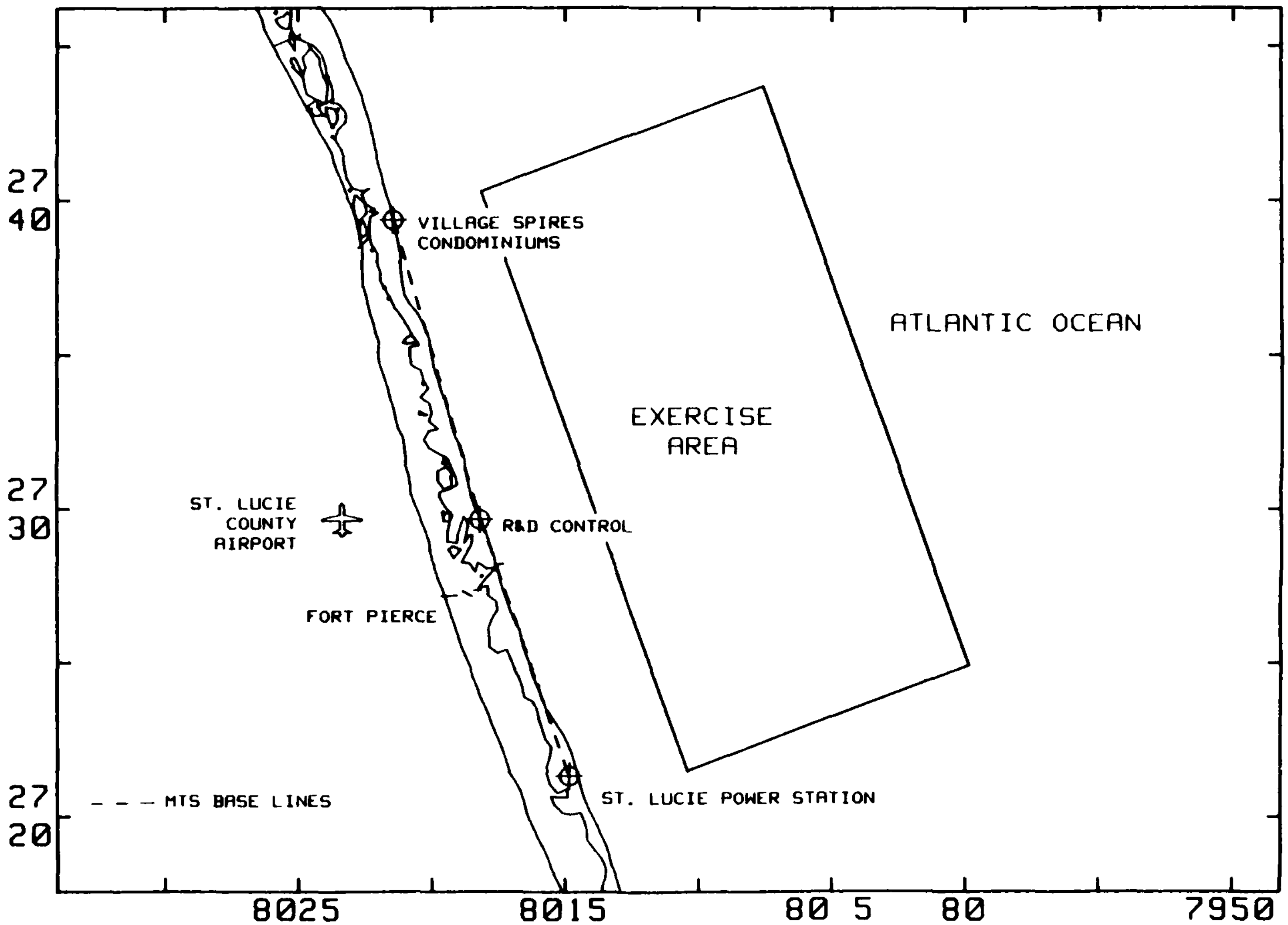


Figure 1-4. Fort Pierce Exercise Area

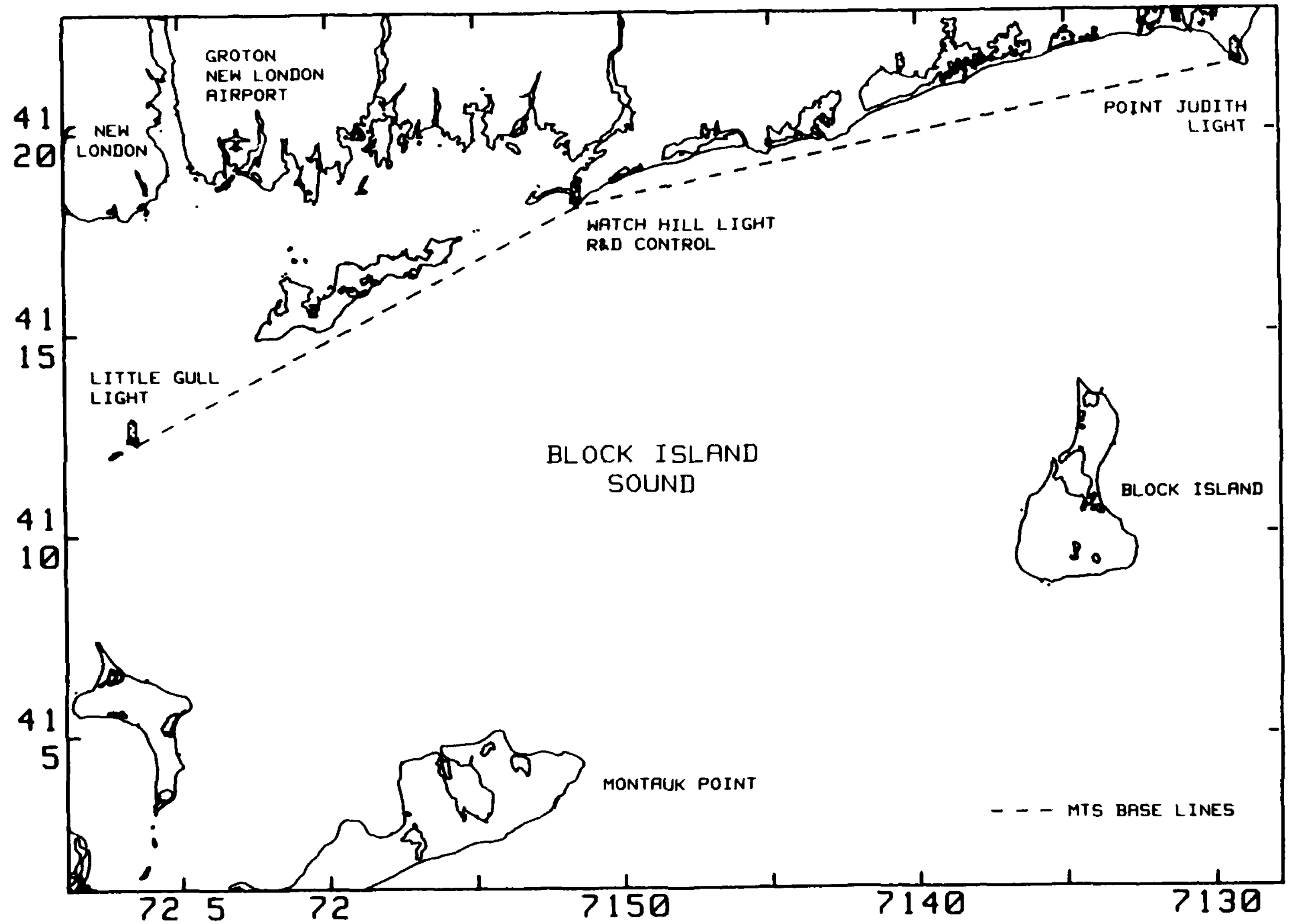


Figure 1-5. Block Island Sound Exercise Area

1.3.3 Targets

Seven types of search targets have been used to date in the NVG evaluations. Targets deployed without lights have included simulated PIWs with retroreflective tape-equipped personal floatation devices (PFDs), 4- to 6- person life rafts without retroreflective tape, 4- to 6-person life rafts with retroreflective tape applied in accordance with Safety of Life at Sea (SOLAS) specifications, and 18- and 21-foot boats. The PIW targets have also been tested with three types of lights attached to their PFDs. During the fall 1989 experiment a military-issue, 1-second "firefly" strobe light was evaluated. Table 1-1 provides the salient characteristics of each target type. Figures 1-6 through 1-10 provide representative photographs of these targets.

Table 1-1. NVG Target Descriptions

TARGET (qty)	TARGET DESCRIPTION	DIMENSTIONS length x beam x freeboard (feet)	PRINCIPAL MATERIAL
PIW (10) *	Department store style mannequin w/Type I PFD and retroreflective tape	1.5 x 1.0 x 1.0	Plastic
6-person raft (2)**	Avon or Beaufort w/orange canopy	7.2 dia. x 3.7 ht.	Rubber/ fabric
	Dunlop w/orange canopy	9.0 x 5.5 oval x 3.25 ht.	
4-person raft (2)**	Avon w/orange canopy	6.0 dia. x 3.5 ht.	Rubber/ fabric
	Viking w/orange canopy	5.5 square x 3.5 ht.	
Boat (3)	Rectangular white skiff w/console	18 x 7.5 x 1.6	Fiberglass
Boat (2)	Rectangular white skiff w/console, blue canvas bimini top, and blue bow shelter canvas	21 x 7.7 x 1.6	Fiberglass

* Equipped with either the Personnel Marker Light or red Safety Light attached to the PFD with plastic tie wrap.

** Rafts were deployed with or without the retroreflective tape exposed.

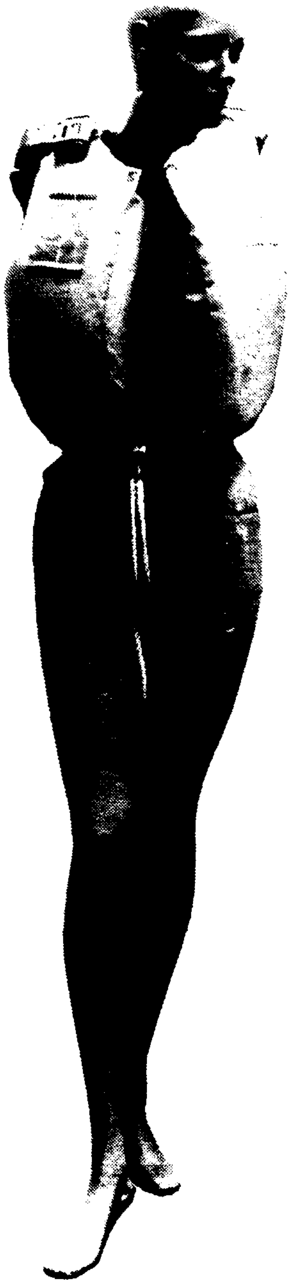


Figure 1-6. PIW Target

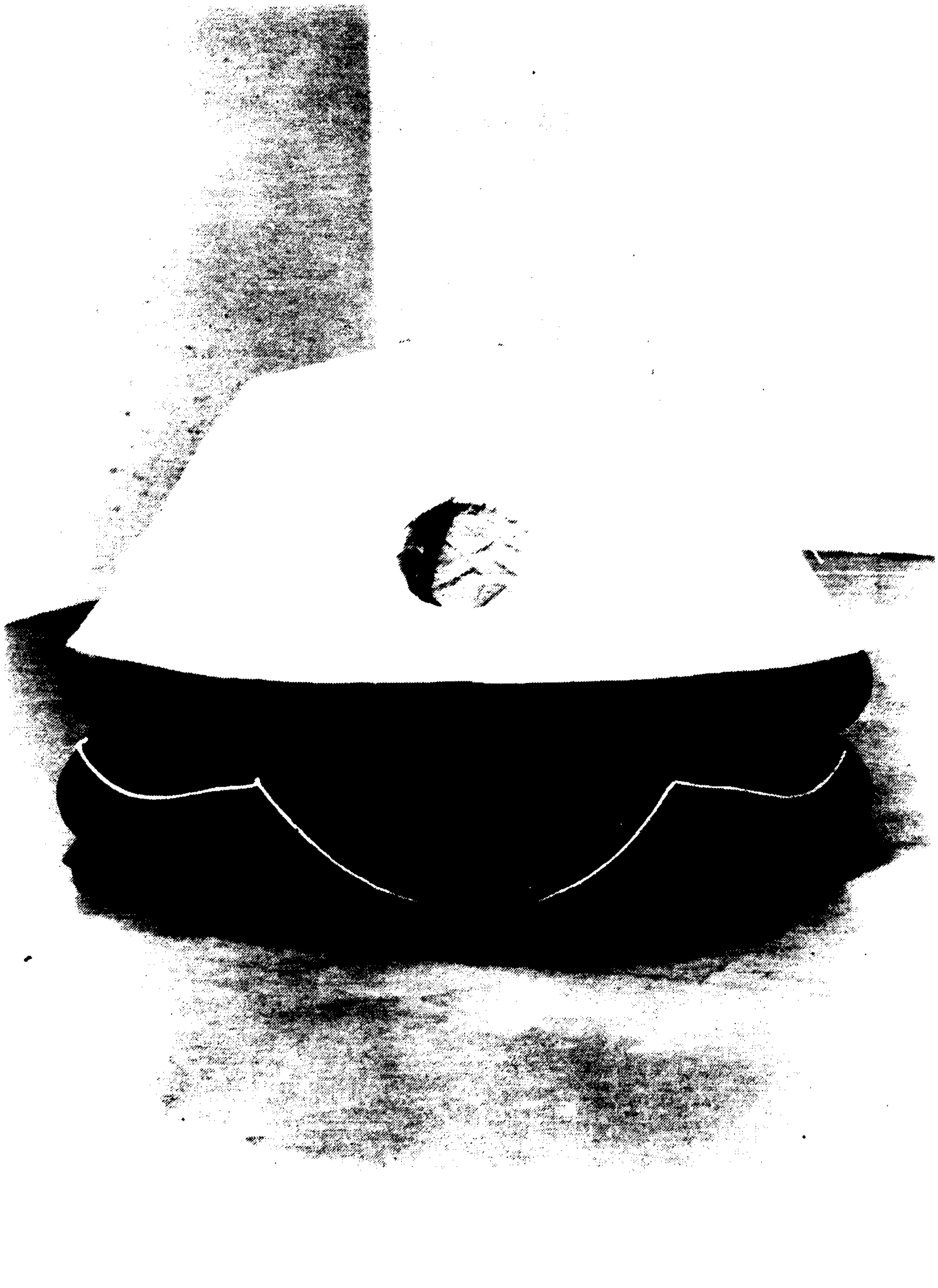


Figure 1-7. Six-Person Life Raft Target Without Retroreflective Tape

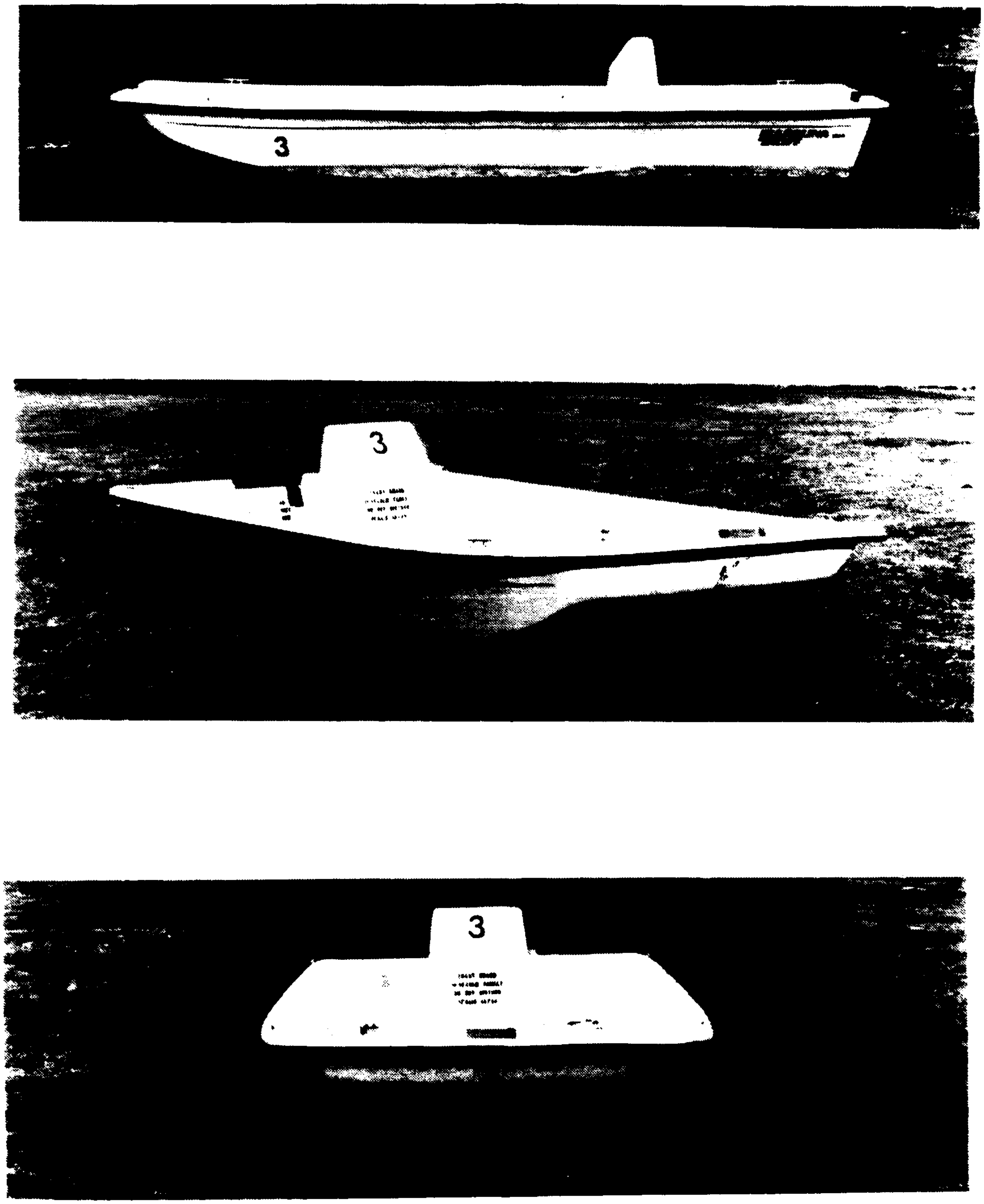


Figure 1-8. Eighteen-Foot Boat Target

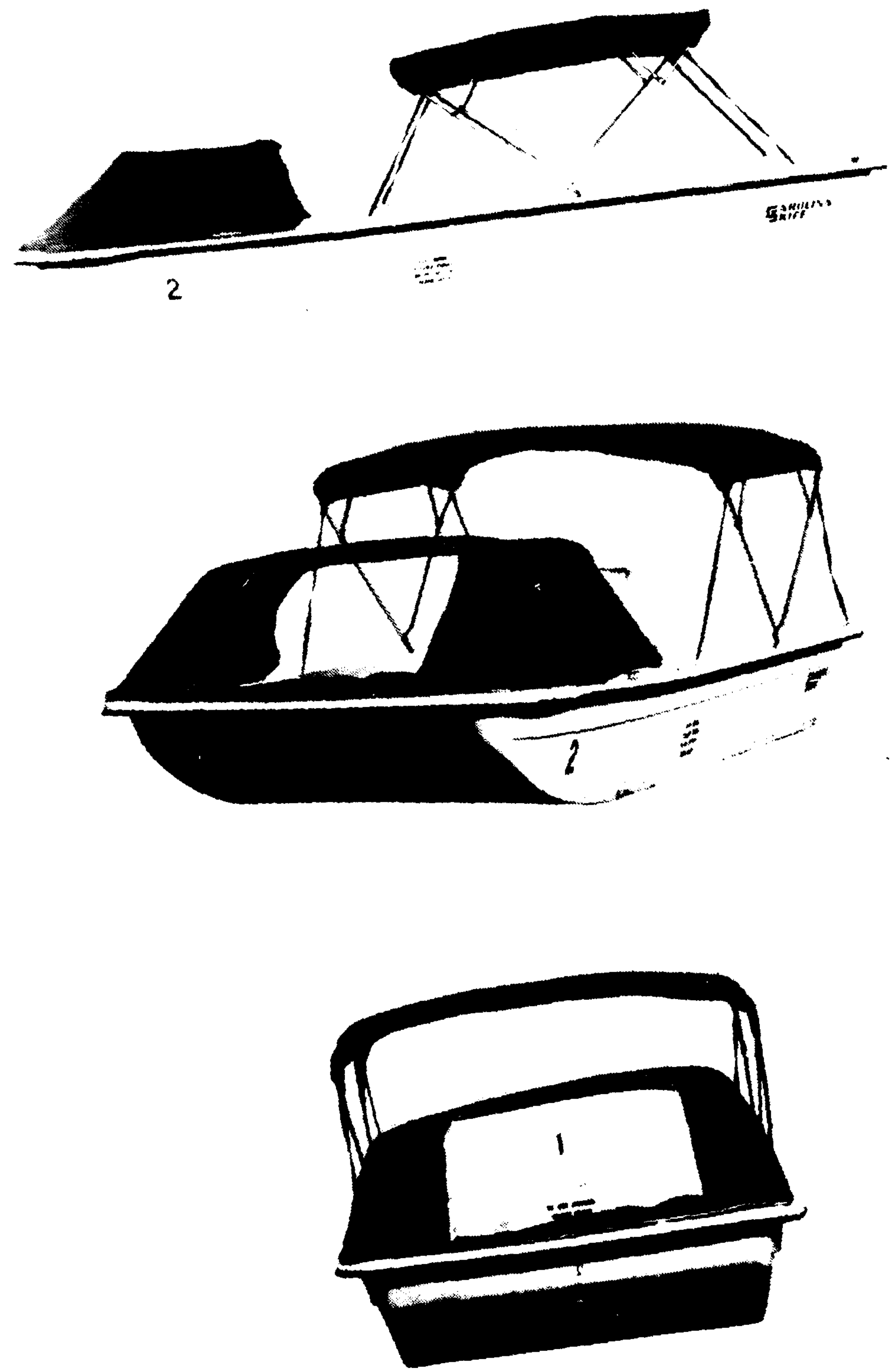


Figure 1-9. Twenty-One Foot Boat Target With Canvas

Figure 1-10. Four-Person Life Raft With Retroreflective Tape
Applied in Accordance With SOLAS Specifications

During the spring 1990 experiment, both green and red chemical lights were tested. The chemical lights were Cyalume devices manufactured by the American Cyanamid Corporation. The green light was a Coast Guard-issue personnel marker light (PML), shown in figure 1-11A. The red light was a red Safety Light stick, shown in figure 1-11B. The brightness of the two chemical lights is plotted in arbitrary units as a function of wavelength in figure 1-12. Two aspects of figure 1-12 are worthy of note. First, most of the PML's energy is eliminated by the minus-blue filter on the ANVIS goggles. Only wavelengths longer than 625 nanometers are intensified by the ANVIS, making the PMLs very difficult to detect. Second, the brightness of both chemical lights diminishes rapidly after activation so that there is about a fivefold decrease in peak output after one hour. Brightness remains relatively stable for several hours after this time.

Data were collected for five of the seven target types during the spring 1990 experiment. No new data were collected for PIWs with retroreflective tape only or for PIWs with strobe lights; thus, no discussion of these targets will be included in this report.

During the experiments, boat and life raft targets were sometimes deployed together on the same night, but PIWs were never mixed with the larger targets. When PIWs were deployed with lights, the lights were all of the same type. PIWs without lights were never mixed with light-equipped PIW targets.

All targets were anchored at randomly-selected positions within the assigned search area each night before data collection started and recovered after all searching was completed. Target positions were selected by superimposing a 5 by 5 block grid (25 blocks total) on the assigned search area, generating a random grid number (1 to 25) for each target, and manually selecting a location for each target within its grid. Specific target positions within grids block were assigned with consideration given to bottom depth/type, currents, local shipping/fishing activity, and proximity of other targets.

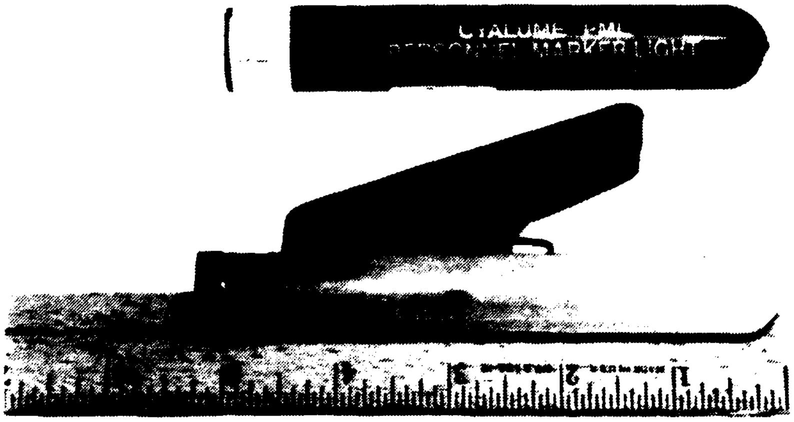


Figure 1-11A. Green Cyalume Personnel Marker Light (PML)

Figure 1-11B. Red Cyalume Safety Light

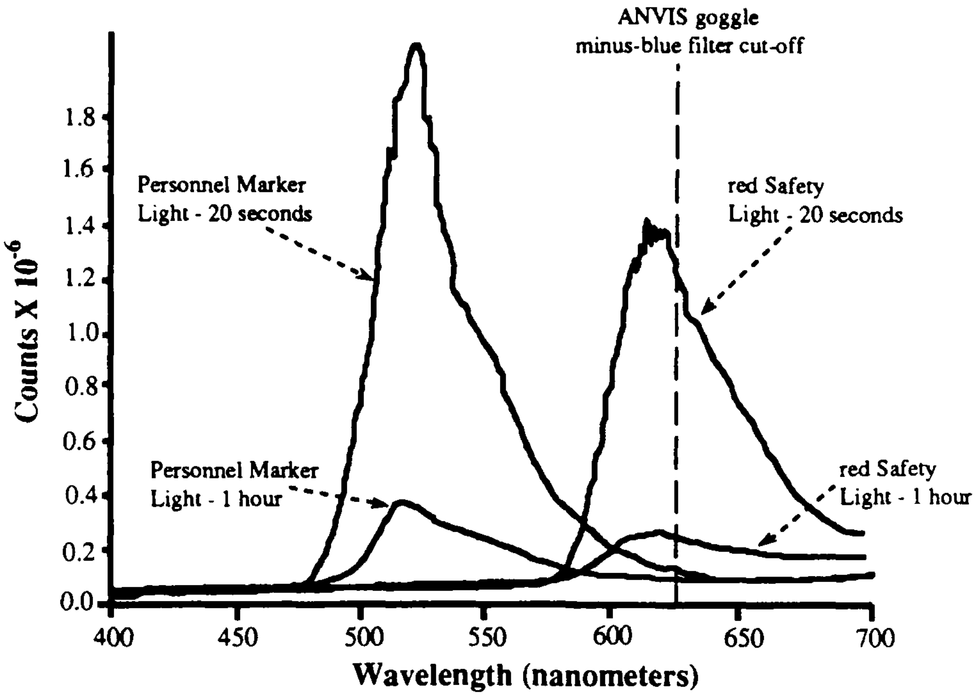


Figure 1-12. Brightness Versus Wavelength and Time for PML and Red Safety Light (USCG Research and Development Center Laboratory Measurements)

1.3.4 Experiment Design and Conduct

Detection data were obtained by conducting operationally-realistic NVG searches using parallel single-unit (PS) and creeping line single-unit (CS) search patterns as defined in reference 9. Track spacing and search area dimensions were chosen to provide target detection opportunities at a variety of lateral ranges. Track spacing for boat and life raft targets was initially set at 2 nmi, which approximates the daylight sweep width for these targets when visibility is about 5 nmi. Early data collection in Florida, however, indicated that nearly all detections of these targets were made at distances less than 1 nmi. Subsequently, most boat and raft searches were conducted using 1-nmi track spacing, with 0.5-nmi spacing used when seas were particularly choppy. A 1-nmi track spacing was used during all searches for PIWs equipped with chemical lights. Figures 1-13 and 1-14 illustrate the type of search instructions that were provided to participating SRUs during the experiments. Helicopters typically searched at a 300-foot altitude and used a 60-knot

Geographic Analysis, Archiving & Display Station
Night Vision Goggles - Block Island Sound

Search Plan No.   Creeping Line Search

Center: 41°12.5 N 71°48 W   AXES: Major: 120/300°T Minor: 030/210°T
START: 41°11.22N 71°54.35W Right Length: 8.00 nm Track Spacing: 1.00 nm
Speed: 90 kts Time: 00:42 Width: 8.00 nm Track Miles: 63.00 nm
41°11.04 71°55.26   41°17.96 71°49.94   41°13.96 71°40.72   41°07.04 71°46.04

Waypoint	Latitude	Longitude	Course	Range	Cumulative Distance
1	41°11.22N	71°54.35W			
2	41°17.28N	71°49.7 W	030 °T	7 nm	7 nm
3	41°16.78N	71°48.55W	120 °T	1 nm	8 nm
4	41°10.72N	71°53.2 W	210 °T	7 nm	15 nm
5	41°10.22N	71°52.05W	120 °T	1 nm	16 nm
6	41°16.28N	71°47.4 W	030 °T	7 nm	23 nm
7	41°15.78N	71°46.24W	120 °T	1 nm	24 nm
8	41°09.72N	71°50.9 W	210 °T	7 nm	31 nm
9	41°09.22N	71°49.75W	120 °T	1 nm	32 nm
10	41°15.28N	71°45.09W	030 °T	7 nm	39 nm
11	41°14.78N	71°43.94W	120 °T	1 nm	40 nm
12	41°08.72N	71°48.59W	210 °T	7 nm	47 nm
13	41°08.22N	71°47.44W	120 °T	1 nm	48 nm
14	41°14.28N	71°42.79W	030 °T	7 nm	55 nm
15	41°13.78N	71°41.64W	120 °T	1 nm	56 nm
16	41°07.72N	71°46.29W	210 °T	7 nm	63 nm

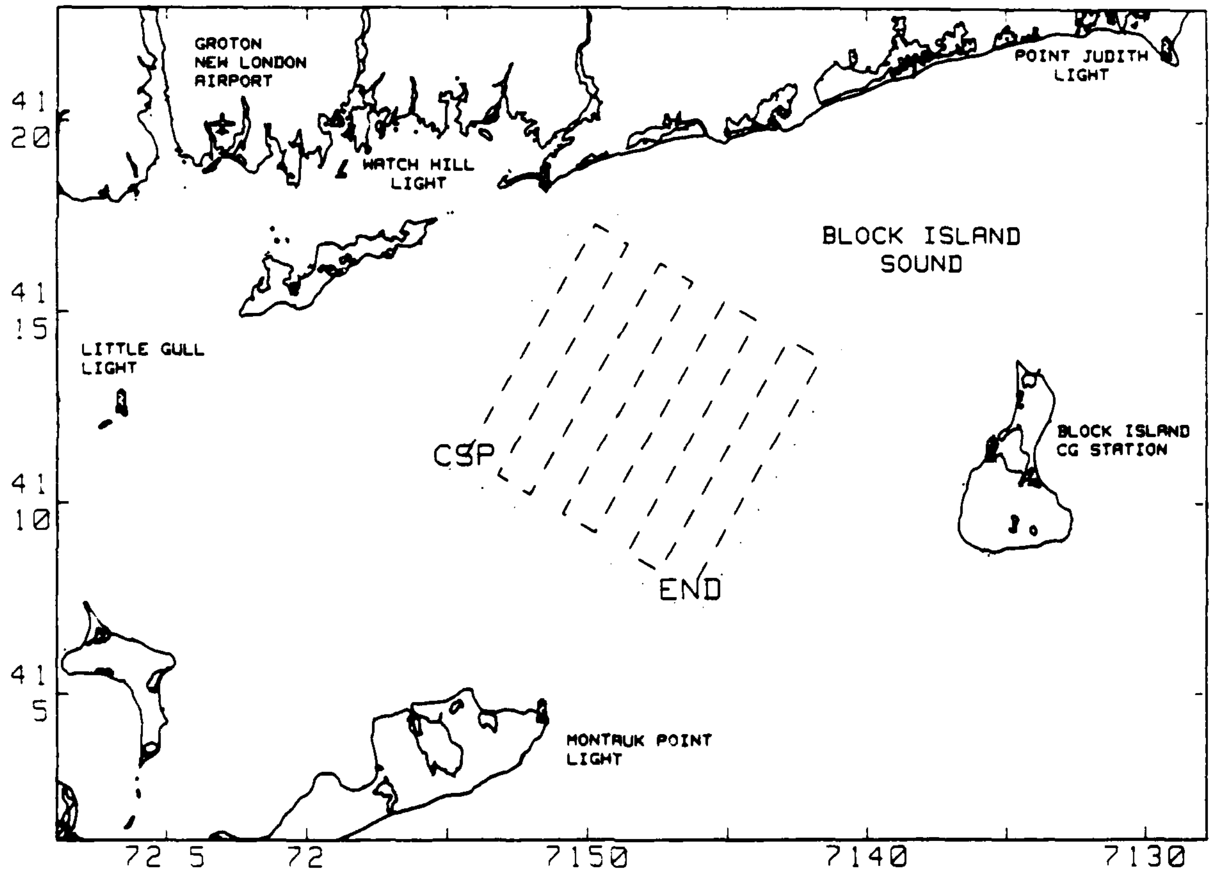


Figure 1-13. Example of Search Instructions Provided to Helicopter (Life Raft and Small Boat Targets)

Geographic Analysis, Archiving & Display Station
Night Vision Goggles - Block Island Sound

Search Plan No. Parallel Search

Center: 41°17.1 N 71°45.4 W AXES: Major: 075/255°T Minor: 165/345°T
START: 41°17.34N 71°50.65W Right Length: 8.00 nm Track Spacing: .50 nm
Speed: 15.0 kts Time: 03:10 Width: 3.00 nm Track Miles: 47.50 nm
Corners of search area: Area of this search: 24 sq nm
41°17.51 71°51.06 41°19.58 71°40.77 41°16.69 71°39.74 41°14.62 71°50.02

Waypoint	Latitude	Longitude	Course	Range	Cumulative Distance
1	41°17.34N	71°50.65W			
2	41°19.28N	71°41.01W	075 °T	7.5 nm	7.5 nm
3	41°18.8 N	71°40.84W	165 °T	.5 nm	8 nm
4	41°16.85N	71°50.48W	255 °T	7.5 nm	15.5 nm
5	41°16.37N	71°50.31W	165 °T	.5 nm	16 nm
6	41°18.31N	71°40.66W	075 °T	7.5 nm	23.5 nm
7	41°17.83N	71°40.49W	165 °T	.5 nm	24 nm
8	41°15.89N	71°50.13W	255 °T	7.5 nm	31.5 nm
9	41°15.4 N	71°49.96W	165 °T	.5 nm	32 nm
10	41°17.35N	71°40.32W	075 °T	7.5 nm	39.5 nm
11	41°16.96N	71°40.15W	165 °T	.5 nm	40 nm
12	41°14.92N	71°49.79W	255 °T	7.5 nm	47.5 nm

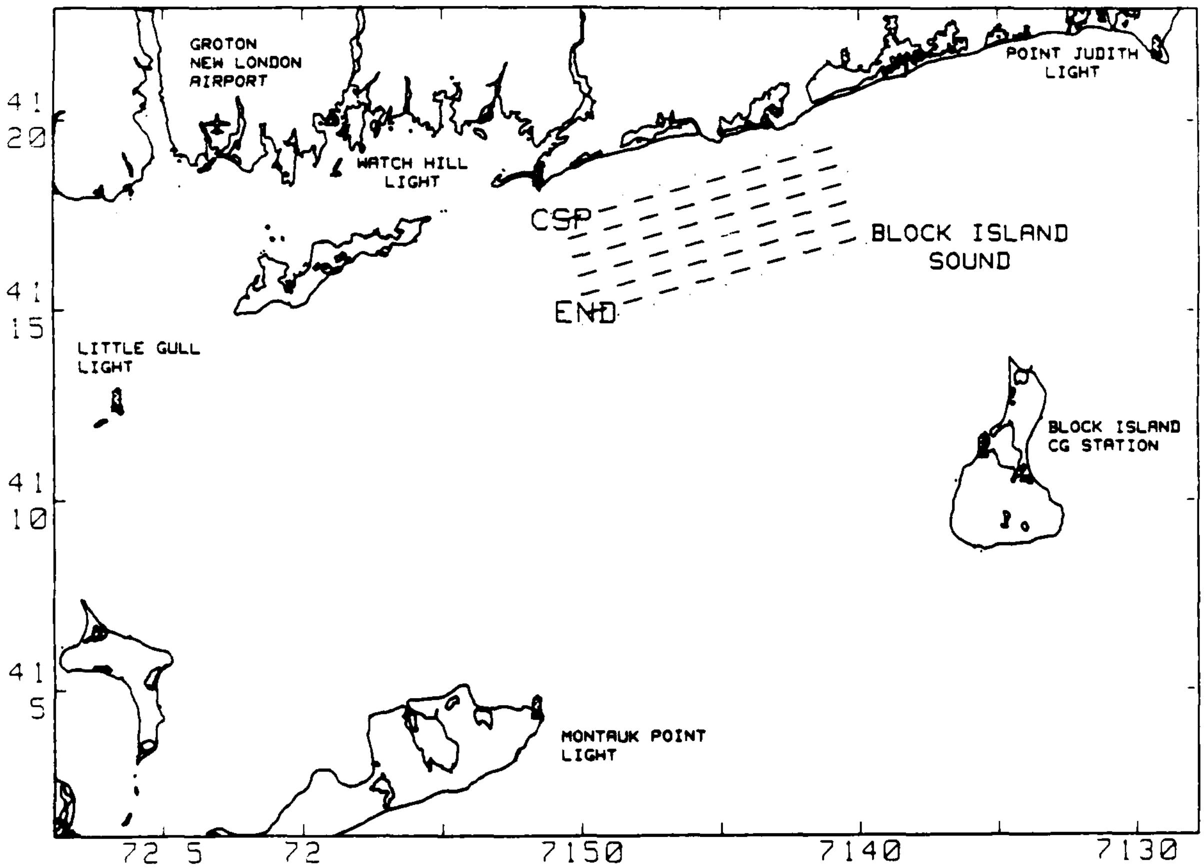


Figure 1-14. Example of Search Instructions Provided to UTBs (PIW Targets)

ground speed for unlit PIW targets and a 90-knot ground speed for all other targets. UTBs used search speeds between 9 and 20 knots, depending on sea conditions. All search parameters were communicated to SRUs by means of a SAR Exercise (SAREX) message sent 12 to 24 hours before scheduled data collection.

In the interest of realism, SRU crews were composed of personnel from the normal complement at their respective air or boat stations. With the exception of the helicopter pilots, special training for the crews in the adjustment, care, and use of NVGs was usually limited to briefings and demonstrations by the R&D Center Test Manager. Except for some of the helicopter pilots who had prior NVG flight experience in the Army, most SRU crewmembers had very little or no operational experience with NVGs. These experience and training levels are representative of what can currently be expected at many Coast Guard SAR facilities where NVGs are available. The SRU crews were instructed to treat the data collection sorties as they would an actual SAR case. The crews were encouraged to maintain motivational levels that would prevail during an actual SAR mission and to conduct operations as they normally would, with one key exception. In the interest of data collection efficiency, no diversions from the assigned search pattern were made by the SRUs for the purpose of confirming target sightings. Target confirmation was made through post-experiment data analysis.

Targets were anchored within the search area each night and were seldom moved until recovered. SRU crews knew which target type(s) were deployed each night but were never told where the targets were located and did not know the exact number of targets deployed each night. Crews were told to report to an onboard data recorder any sighting of an object that could conceivably be one of the search targets.

While NVGs were the primary sensor employed in these searches, a few incidental detections that were made by coxswains and helmsmen with the naked eye or with a radar assist are also included in the UTB data set. Helicopter crewmembers all wore the ANVIS goggles whenever searching and used radar only for avoiding severe weather. The only naked-eye detection made by a helicopter crewmember occurred during the spring 1990 experiment when searching for green chemical lights. This sighting was made by looking beneath the ANVIS eyepieces.

Each night, a data recorder from A&T's field team accompanied each SRU to log human factors data, target detections, and crew comments. Crew information was recorded on the SRU Information Form (figure 1-15). Target detections, crew comments, and general observations were recorded on the NVG Detection Log (figure 1-16).

When a target was sighted, lookouts immediately relayed its relative bearing ("clock" method), its estimated range (expressed as a fraction of the distance to the horizon), and a brief description of its appearance to the data recorder. The data recorder then logged the detection time, relative bearing, range, visibility of the moon, SRU heading, lookout position, and remarks on the NVG Detection Log. Times were synchronized to the nearest second with the MTS clock so that detections could be validated during post-experiment analysis of the logs and SRU track histories. The A&T data recorders were instructed not to assist with the search effort in any way and did not wear NVGs while recording data.

On-scene environmental conditions were recorded using two methods. An A&T technician onboard the chartered workboat recorded environmental data on the Environmental Conditions Summary (figure 1-17). The MiniMet environmental data buoy relayed information to the R&D Control facility over a UHF data link three times per hour. This information was also stored in an internal memory onboard the buoy as a backup.

Figure 1-18 depicts the data messages received from the buoy. Two of the three hourly messages relayed wind data, water temperature, and air temperature at 10 minutes and 40 minutes past the hour. At 30 minutes past the hour, wave spectrum data including significant wave height (H_S) were relayed. The buoy was the preferred environmental data source when both sets of information (work boat and buoy) were available.

SRU INFORMATION FORM

DATE ______________________ MTS TRANSPONDER CODE ______________________

SRU TYPE ____________________ SERIAL NUMBER ______________________

COAST GUARD COMMAND ____

NAVIGATION INPUTS USED
(check all that apply)

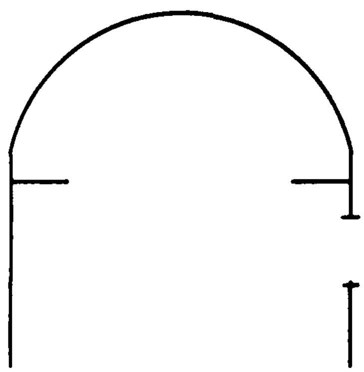
TACAN ___ VOR/DME ___ INS ___ LORAN-C ___ RDF ___ RADAR ___ DEAD REC. ___

CREW NAMES

POSITION	NAME	RANK	FUNCTION	EXPERIENCE W/NVG (hr)
A				
B				
C				
D				
E				
F				

SKETCH (show positions)

Aircraft



Vessel

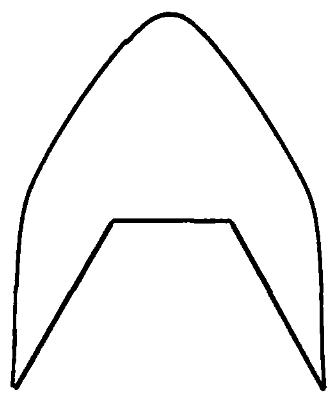


Figure 1-15. SRU Information Form

NVG DETECTION LOG

DATE ____________

AIRCRAFT/BOAT NO. ____________ SEARCH START TIME ____________ SEARCH ____________

TRANSPONDER CODE ____________ SEARCH END TIME ____________ SPEED ____________

NVG MODEL ____________ SEARCH DURATION ____________ ALTITUDE ____________

EVENT/ DETECTION NO.	TIME (HH:MM:SS)	SIGHTING RANGE (rel. to horiz.)	RELATIVE BEARING (deg/clock)	MOON VISIBILE? (Y/N)	SRU HEADING (deg T or M)	LOOKOUT/ POSITION	REMARKS (visibility, precip., fog, target appearance, etc.)

RECORDER: ____________

Figure 1-16. NVG Detection Log

ENVIRONMENTAL CONDITIONS SUMMARY

REPORTING UNIT: ____________________ DATE: ____________________

TIME	SURFACE WIND TRUE SPEED (knts)	SURFACE WIND TRUE DIRECTION (deg M)	CLOUD COVER (tenths)	MOON VISIBLE (Y/N)	VISIBILITY (nmi)	WEATHER DESCRIPTION (clear, rain, fog, ect.)	SEA STATE H* S (ft)	SEA STATE WHITE CAPS (N/SM)	SEA STATE SWELL DIR (deg M)	RELATIVE HUMIDITY (%)	AIR TEMP (°C)	WATER TEMP (°C)
**METHOD OF MEASUREMENT												

* Significant wave height.
**NOTE: Method may be scientific (anemometer, radar, psychrometer, ect.) or an estimate. Indicate method used to measure each parameter.

OBSERVER: ____________________

Figure 1-17. Environmental Conditions Summary Form

```
Z901MET 890927 21 10 045 129 045 045 086 059 178 121 153 259800 439209 00
Buoy #901 - Met. Data - 27 Sep 1989 / 21:10:00
      Vector Wind Speed: 4.5 mps (8.75 knots)
      Vector Wind Direction: 129°M
      Average Wind Speed: 4.5 mps (8.75 knots)
      Average Azimuth Reading: 45°M
      Average Vane Reading: 86°M
      wind Gust: 5.9 mps (11.47 knots)
      Water Temperature: 17.8°C (64°F)
      Air Temperature: 12.1°C (53.8°F)
      Battery Voltage: 15.3 volts
      Loran Time Delays: 25980 / 43920.9   S/N: 0   C/S: 0
      Latitude/Longitude: 41°12.171'N  /  71°47.905'W

1 Z901WAV 890927 21 087 110 104 095 112 113 126 175 174 206 204 239 246
2 Z901WAV 890927 21 239 223 204 206 198 189 193 196 168 189 171 187 205
3 Z901WAV 890927 21 224 241 255 251 245 250 001 004 009
Buoy #901 - Wave Data
      Record #1 - Wave Spectral Values 1 to 13 - 27 Sep 1989 / 21:30:00
        087 110 104 095 112 113 126 175 174 206 204 239 246
      Record #2 - Wave Spectral Values 14 to 26 - 27 Sep 1989 / 21:30:00
        239 223 204 206 198 189 193 196 168 189 171 187 205
      Record #3 - Wave Spectral Values 27 to 32 - 27 Sep 1989 / 21:30:00
        224 241 255 251 245 250
      Scaling Factor: 1
      Significant Wave Height: .4 m (1.3 ft)
      Maximum Wave Period: .9 sec

Z901MET 890927 21 40 051 115 051 045 072 062 178 118 158 259800 43209 00
Buoy #901 - Met. Data - 27 Sep 1989 / 21:40:00
      Vector Wind Speed: 5.1 mps (9.91 knots)
      Vector Wind Direction: 115°M
      Average Wind Speed: 5.1 mps (9.91 knots)
      Average Azimuth Reading: 45°M
      Average Vane Reading: 72°M
      wind Gust: 6.2 mps (12.05 knots)
      Water Temperature: 17.8°C (64°F)
      Air Temperature: 11.8°C (53.2°F)
      Battery Voltage: 15.8 volts
      Loran Time Delays: 25980 / 43920.9   S/N: 0   C/S: 0
      Latitude/Longitude: 41°12.171'N  /  71°47.905'W
```

Figure 1-18. Environmental Data Buoy Message Formats

1.3.5 Tracking and Reconstruction

Target locations and aircraft positions were monitored using the automated MTS consisting of a Motorola Falcon 492 system controlled by a Hewlett-Packard desktop computer. The controlling software system was developed by the R&D Center to provide real-time positioning and tracking with search reconstruction accurate to better than 0.1 nmi. A mobile MTS transponder was installed on the work boat for use in target positioning and on each SRU so that a track history of each search pattern could be generated. SRU positions were recorded continuously by the MTS, displayed in real time on a CRT at R&D Control, and recorded on a microcomputer hard disk every 10 to 30 seconds. Target positions were recorded by obtaining an MTS fix on the workboat when deploying each target, then verifying that each position was unchanged upon target retrieval. A more detailed description of this system can be found in reference 10.

In the Fort Pierce, FL exercise area the tracking system recorded the range from a transponder to the MTS Master Unit located atop a high-rise condominium building in Fort Pierce and from a transponder to the two relay stations (located on a meteorological tower at the Florida Power and Light Company St. Lucie Plant and at the Village Spires condominiums in Riomar). These locations were depicted in figure 1-4. In the Block Island Sound exercise area the tracking system recorded the range from a transponder to the Master Unit located at Watch Hill Light and from a transponder to the two primary relay stations (located at Little Gull Light and Point Judith Light). These locations were depicted in figure 1-5.

Search tracks and target locations were reconstructed by using the recorded target and SRU position data to generate an accurate geographic representation on hard copy plots. On each plot, target positions were plotted using identifying letters and the SRU track was identified by dots and plusses. Plotting the SRU position marks created a trackline history for each search craft. Each position mark was associated with a known time on a hard copy printout that accompanied each plot. Figures 1-19 and 1-20 are MTS-generated reconstruction plots of actual searches that were conducted during the second Block Island Sound experiment. Figure 1-19 depicts the execution by a CH-3E helicopter of the search instructions that were shown in figure 1-13. Figure 1-20 depicts the execution by a 41-foot UTB of the search instructions that were shown in figure 1-14.

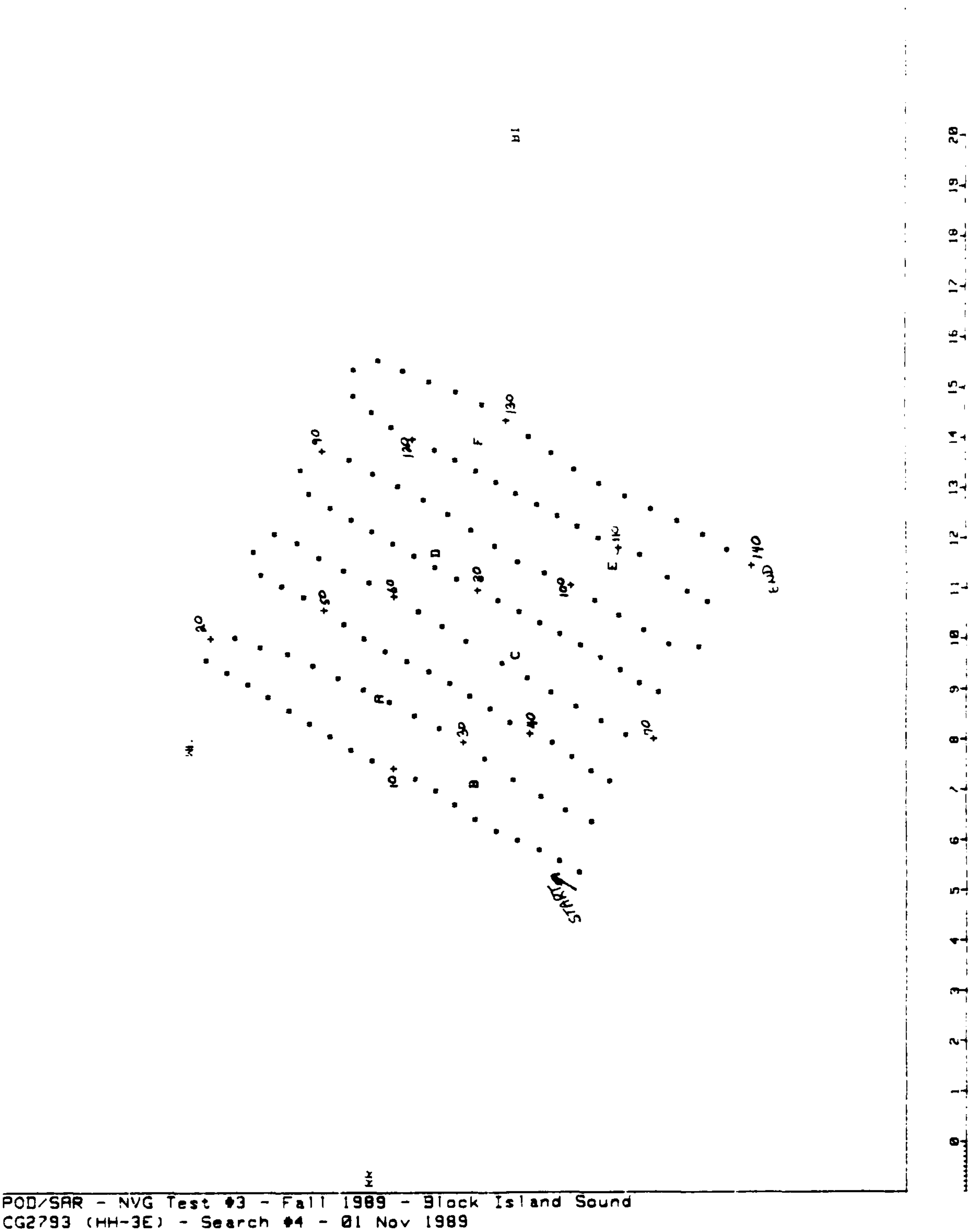


Figure 1-19. MTS Plot of a Typical Helicopter Search

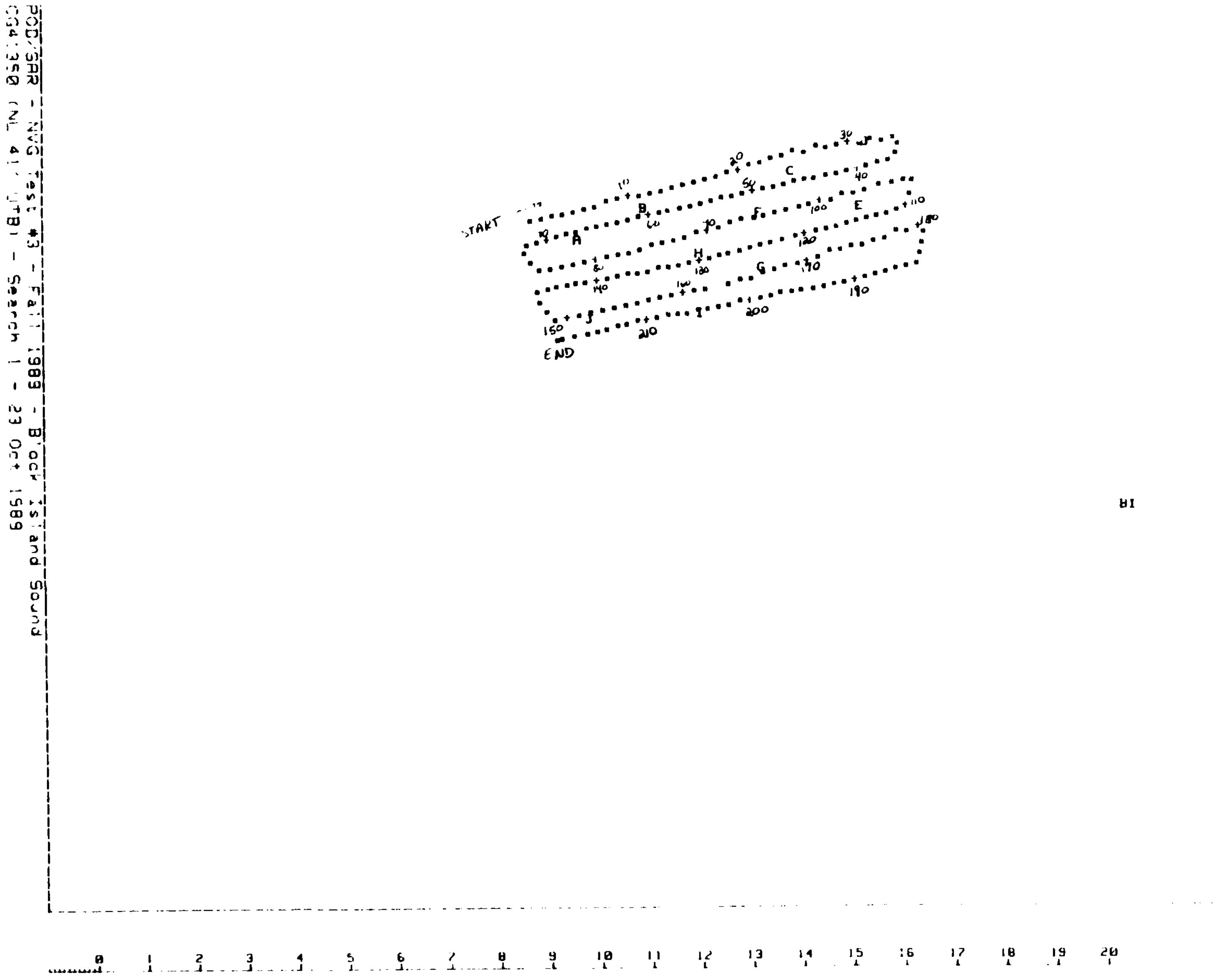


Figure 1-20. MTS Plot of a Typical UTB Search

Analysts used the MTS plots and NVG Detection Logs to determine which R&D Center targets were detected and which were missed on each leg of an SRU's search pattern. Normally, a target was considered an opportunity for detection on any given search leg if the SRU passed it within the assigned track spacing distance. Occasionally, analysts considered targets to be detection opportunities at distances greater than the track spacing. This was done when, on a given night, an SRU made one or more detections at lateral ranges that, when multiplied by 1.5, exceeded the assigned track spacing. In such instances, this computed distance (1.5 times maximum lateral range of detection) was used instead of the track spacing to determine which targets were considered valid opportunities for detection on each search leg. This rule, although somewhat arbitrary, provided sufficient data to identify an asymptotic limit to the NVG lateral range curve (to be discussed in section 1.4) without adding a large number of meaningless (very long-range) target misses to the data set.

If a logged target report could be correlated with the position of a given R&D Center target, it was considered a detection. Analysts performed this correlation by using the time of a given detection reported in the NVG Detection Log to locate the search craft on the hard copy MTS plot. The range and bearing information for that detection was then compared to target positions on the MTS plot, and a detection validity determination was made. A miss was recorded for any target detection opportunity that could not be correlated with a logged detection report on a particular search leg. An accurate lateral range measurement was then made on the MTS plot for each detection or miss. These detections and misses, along with associated search parameters and environmental conditions, were compiled into computer data files for analysis. Data files for the three 1989 experiments are listed in Volume II of reference 1. Data files for the spring 1990 experiment are listed in the appendix of this report.

1.3.6 Range of Parameters Tested

A total of 25 potentially-significant search parameters were recorded for each valid target detection opportunity. These parameters can be broadly classified as relating to the target, the SRU, the environment, ambient light, and human factors. These search parameters and their units of measure are as follows.

PARAMETER		UNIT OF MEASURE
	Target-Related	
1.	Target Type	PIWs: retroreflective tape or chemical light Rafts: with or without retroreflective tape Boats: 18-foot without canvas or 21-foot with canvas
2.	Lateral Range*	nautical miles
	SRU-Related	
3.	NVG Type	41-foot UTB: AN/PVS-5 or AN/PVS-7 Helicopters: AN/AVS-6 only
4.	Search Speed	knots
5.	Search Altitude	feet (helicopter only)
	Environment - Related	
6.	Precipitation Level	none/light/moderate/heavy
7.	Visibility	nautical miles
8.	Wind Speed	knots
9.	Cloud Cover	tenths of sky obscured
10.	Significant Wave Height	feet
11.	Whitecap Coverage	none/light/heavy
12.	Relative Wave Direction	wave fronts traveling into/away from/across line-of-sight to target at SRU's closest point of approach (if target missed) or at time of detection
13.	Relative Humidity	percent
14.	Air Temperature	degrees Celsius
15.	Water Temperature	degrees Celsius

*See section 1.4.1 for definition.

PARAMETER (Cont'd)	UNIT OF MEASURE (Cont'd)
Ambient Light - Related	
16. Relative Azimuth of Artificial Light	light source located along/away from/across line-of-sight to target at SRU's closest point of approach (if target missed) or at time of detection
17. Artificial Light Level	rural/suburban/urban
18. Moon Elevation	degrees above or below the horizon
19. Moon Visible (from SRU)	yes/no
20. Relative Azimuth of the Moon	moon (visible or not) located along/away from/across line-of-sight to target at SRU's closest point of approach (if target missed) or at time of detection
21. Moon Phase	none, 1/4, 1/2, 3/4, full
Human Factors - Related	
22. Lookout Position†	location onboard SRU
23. Lookout ID†	individual identifier
24. Lookout NVG Experience†	hours
25. Time on Task	hours (actually searching)

The range of target types evaluated was discussed in section 1.3.3. Lateral range for target opportunities varied from 0 to 2 nmi for boat and life raft targets and PIW targets with chemical lights.

The types of NVGs used on each SRU were discussed in section 1.2. Helicopter search speed was approximately 60 knots for PIW targets without lights and approximately 90 knots for boat, raft, and PIW targets with lights. UTB search speeds varied between 9 and 20 knots depending on sea conditions. Search altitude for the helicopter was held constant at about 300 feet above the sea surface.

†Items 22 through 24 were recorded for detections only.

The range of environmental parameters encountered over the four experiments is summarized in table 1-2. Relative wave direction has been omitted from the table because all three possibilities are well-represented. Moon elevation and moon phase are also included in table 1-2. Artificial light levels were either rural or suburban in both locations.

A total of 34 individual helicopter lookouts and 89 UTB lookouts (not all of whom wore NVGs) are represented in the data set. NVG experience ranged from 0 to 189 hours for helicopter crewmembers and from 0 to 50 hours for UTB crewmembers. Time on task ranged from 0 to 5.9 hours for the helicopter crews and from 0 to 6.2 hours for UTB crews.

All remaining parameters were well-represented over their range of possible values.

1.4 ANALYSIS APPROACH

1.4.1 Measure of Search Performance

The primary performance measure used by SAR mission coordinators to plan searches is *sweep width* (W). Because this NVG evaluation is intended to support improved Coast Guard SAR mission planning, sweep width was chosen as the measure of search performance to be developed during data analysis. Sweep width is a single-number summation of a more complex range/detection probability relationship. Mathematically,

$$W = \int_{-\infty}^{+\infty} P(x)dx ,$$

where

x = Lateral range (i.e., closest point of approach) to targets of opportunity (see figure 1-21), and

P(x) = Target detection probability at lateral range x.

Figure 1-22 shows a typical P(x) curve as a function of lateral range. In this figure, x is the lateral range of detection opportunities.

Table 1-2. Range of Environmental and Moon Parameters Encountered

SRU/ TARGET	ENVIRONMENTAL PARAMETERS									MOON	
	Precipitation Level	Visibility (nmi)	Wind Speed (knots)	Cloud Cover (tenths)	Significant Wave Height (ft)	Whitecap Coverage	Relative Humidity (percent)	Air Temperature (deg. C)	Water Temperature (deg. C)	Elevation (degrees)	Phase
Helo/Boats	0 to 1	1.5 to 15	1.6 to 20	0 to 1	1.3 to 4.3	0 to 2	61 to 96	10.4 to 24.3	13.4 to 24.2	-68 to 65	none to full
Helo/PIW w/Red Safety Lights	0 to 3	15 to 15	5 to 15	.1 to .9	2 to 4.3	0 to 1	61 to 86	22.2 to 26	22 to 24	-67 to 19	quarter to 3 quarter
Helo/PIW w/Personnel Marker Light	0 to 0	15 to 15	5 to 10	.2 to .4	5.2 to 6.2	0 to 0	63 to 69	21.1 to 21.5	20.8 to 22.2	47 to 57	full
Helo/Rafts w/Retroreflective Tape	0 to 0	15 to 15	8 to 16	0 to .4	3.0 to 4.3	0 to 0	60 to 71	21.7 to 23.0	21.8 to 22.5	-66 to 22	quarter to full
Helo/Rafts Without Retroreflective Tape	0 to 3	1.5 to 15	3 to 16	0 to .1	1.6 to 5.2	0 to 2	61 to 100	10.4 to 24.3	13.4 to 23.0	-69 to 69	none to full
UTB/ Boats	0 to 1	1.5 to 15	1.6 to 20	0 to 10	1.3 to 4.3	0 to 2	61 to 96	5.5 to 24.3	13.4 to 24.2	-60 to 51	none to full
UTB/PIW w/Red Safety Lights	0 to 3	15 to 15	5 to 15	.3 to .9	2 to 3.6	0 to 1	74 to 78	23.3 to 26	23.5 to 24	-64 to 6	quarter to 3 quarter
UTB/Rafts w/Retroreflective Tape	0 to 0	15 to 15	7 to 16	.1 to .4	3.5 to 4.3	0 to 2	60 to 71	21.6 to 23.9	21.4 to 22.1	-63 to 38	quarter to full
UTB/Rafts Without Retroreflective Tape	0 to 2	1.5 to 15	2 to 24	0 to 1.0	1.3 to 4.6	0 to 2	61 to 100	6.1 to 24	13.5 to 23.6	-62 to 52	none to full

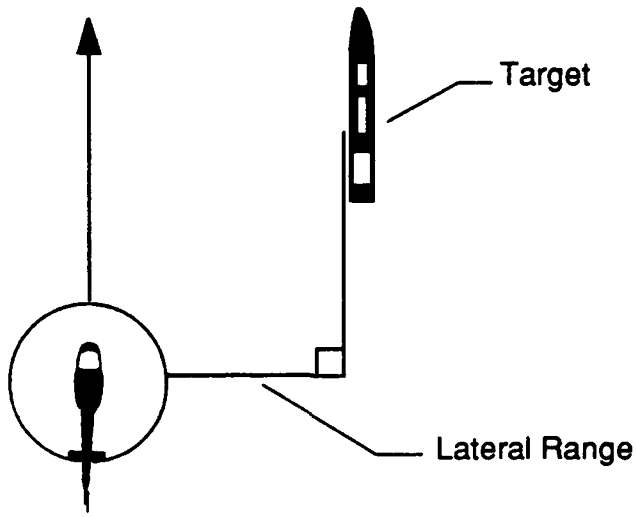


Figure 1-21. Definition of Lateral Range

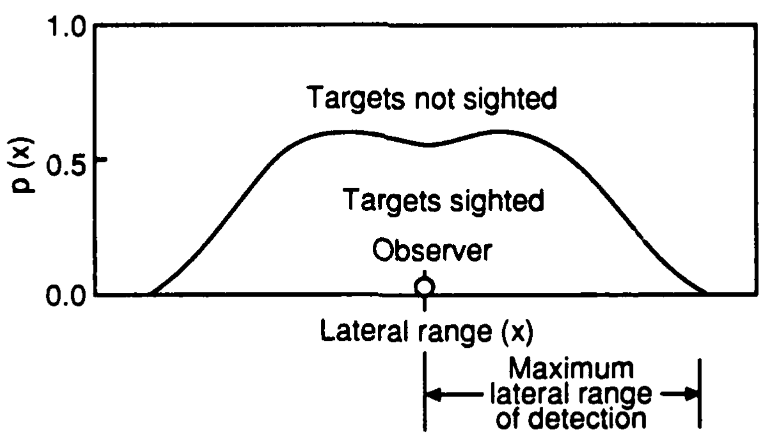


Figure 1-22. Relationship of Targets Detected to Targets Not Detected

Conceptually, sweep width is the numerical value obtained by choosing a value of lateral range less than the maximum detection distance for any given sweep so that scattered targets that may be detected beyond the limits of sweep width are equal in number to those that may be missed within those limits. Figure 1-23 (I and II) illustrates this concept of sweep width. The number of targets missed inside the distance W is indicated by the shaded portion near the top middle of the rectangle (area A); the number of targets sighted beyond the distance W out to maximum detection range (MAX R_D) is indicated by the shaded portion at each end of the rectangle (areas B). Referring only to the shaded areas, when the number of targets missed equals the number of targets sighted (area A = sum of areas B), sweep width is defined. A detailed mathematical development and explanation of sweep width can be found in reference 11.

1.4.2 Analysis of Search Data

Three primary questions were addressed in this interim analysis of NVG detection data.

1. Which of the 25 search parameters identified in section 1.3.6 exerted significant influence on the detection performance of the SRUs against the 5 target types tested during the spring 1990 experiment?

2. What are the NVG sweep width estimates for various combinations of significant search parameters?

3. What guidance for NVG use onboard Coast Guard SRUs can be developed based on the quantitative analyses described above and the subjective comments and observations obtained from experiment participants?

1.4.2.1 Development of Raw Data

After each experiment, the MTS plots and NVG detection logs were used as described in section 1.3.5 to determine which SRU-target encounters were valid detection opportunities, and which of those opportunities resulted in successful target detections by the SRUs. The analyst listed each target detection opportunity on a raw data sheet along with a detection/miss indicator. Values for the 25 search parameters listed in section 1.3.6 were then obtained for each listed

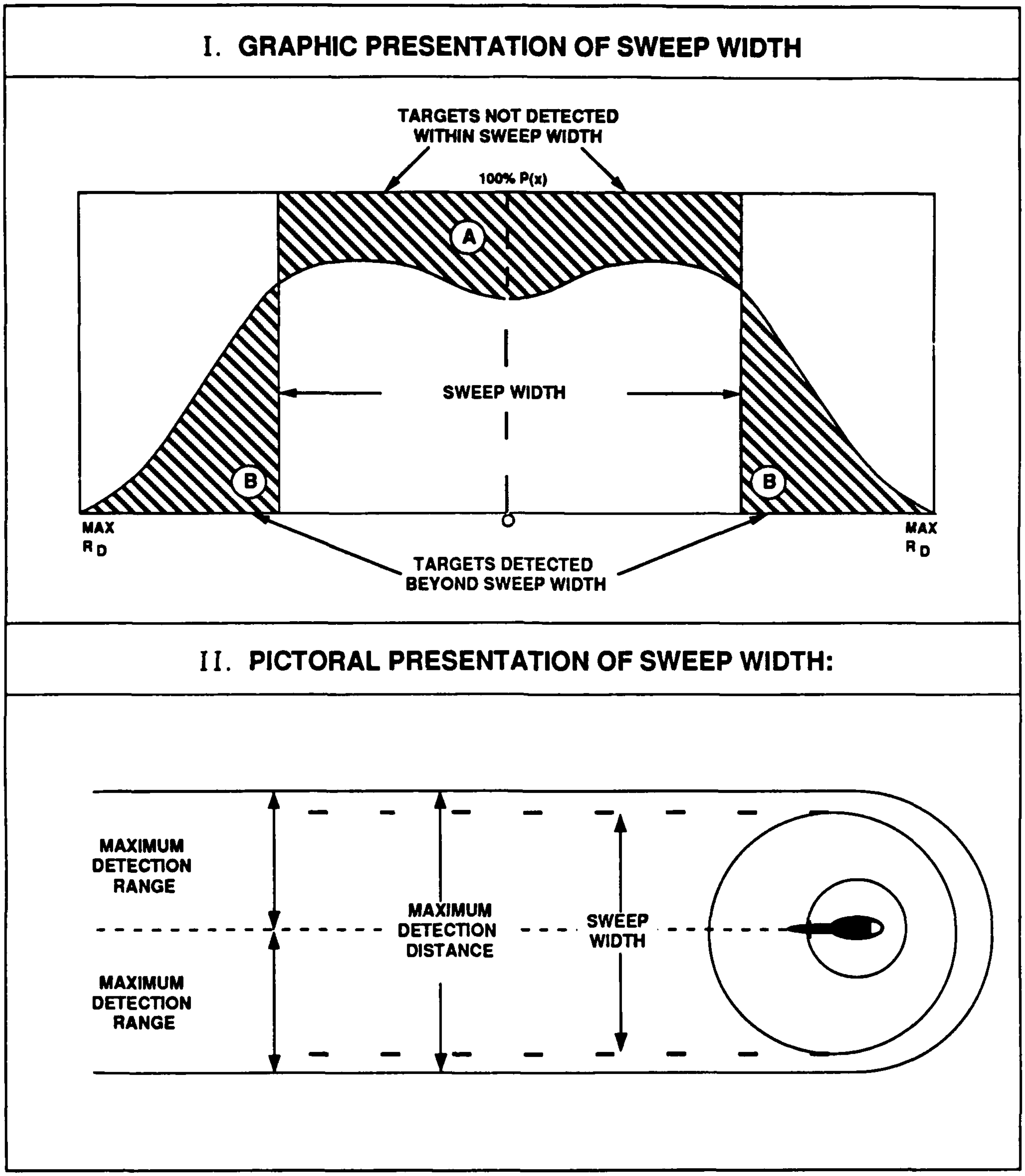


Figure 1-23. Graphic and Pictoral Presentation of Sweep Width

detection opportunity by consulting appropriate logs and environmental data buoy messages. A separate raw data sheet was completed for each search that was conducted by each SRU. The contents of these raw data sheets were entered into computer data files on an Apple Macintosh IIcx computer using spreadsheet software and stored on magnetic disk. A distinct data file was constructed for each SRU for each night it participated in data collection. Hard copies of these data files are provided in Appendix A of this report and in Volume II of reference 1.

From these single-SRU data files, eight aggregate raw data files were built; one file for each SRU/target type combination evaluated (two SRUs times four target types). These eight raw data files served as input to all subsequent data sorting and statistical analysis routines used for this evaluation.

1.4.2.2 Data Sorting and Statistics

Once the eight files of raw data were entered and verified to be correct on the computer, basic statistics were obtained to characterize the data sets. A commercial statistics and graphics software package purchased from SYSTAT, Inc. was used to perform this phase of the data analysis.

Various SYSTAT routines were used to produce simple statistics, histograms, and scatter plots showing the range of search parameter values and their combinations present in each data set. The minimum, maximum, mean, and standard deviation values for each search parameter in the eight data sets were obtained to determine the range of search conditions represented in each data set. Histograms showing the distribution of values for various parameters of interest were obtained to determine which search conditions were well-represented within each data set and which were not. Scatterplots depicting which combinations of search parameters were represented in each data set were also produced.

Once the data sets were characterized in this manner, logistic multivariate regression analysis was used to determine which search parameters exerted significant influence on NVG detection performance and to develop lateral range curves from which NVG sweep widths could be computed.

1.4.2.3 LOGIT Multivariate Regression Model

Multivariate logistic regression models have proven to be appropriate analysis tools for fitting Coast Guard visual search data where the dependent variable is a discrete response (i.e., detection/no detection). The detection data from this NVG evaluation have been analyzed using a commercially-available software package from SYSTAT, Inc. called LOGIT. LOGIT is an add-on module to SYSTAT's standard statistical analysis and graphics software package.

This type of regression model is useful in quantifying the relationship between independent variables (x_i) and a probability of interest, R (in this case the probability of detecting a target). The independent variables (x_i) can be continuous (e.g., range, wave height, wind speed) or binary (e.g., high/low altitude, SRU type 0 or 1). For example, A&T's logistic regression model, LOGODDS, has been used with great success during Improvement in Probability of Detection in Search and Rescue (POD/SAR) Project visual search performance analyses (reference 10). The LOGODDS model was shown to be an effective means of identifying statistically-significant search parameters and of quantifying their influence on the target detection probability versus lateral range relationship. This functional relationship, commonly referred to as the lateral range curve, provides a basis for computing sweep widths.

The equation for target detection probability that is used in the logistic regression model is

$$R = \frac{1}{1 + e^{-\lambda}},$$

where

R = target detection probability for a given searcher - target encounter,

λ = $a_0 + a_1x_1 + a_2x_2 + a_3x_3 + \ldots + a_nx_n$,

a_i = fitting coefficients (determined by computer program), and

x_i = independent variable values.

The method of maximum log-likelihood is employed in the model to optimize values of the coefficients a_i. A detailed theoretical development of the logistic regression analysis methodology is given in reference 12.

A logistic regression model has the following advantages over other regression models and statistical methods.

1. The model implicitly contains the assumption that $0 \leq R \leq 1.0$; a linear model does not contain this assumption unless it is added to the model (in which case computation can become very difficult).

2. The model is analogous to normal-theory linear models; therefore, analysis of variance and regression implications can be drawn from the model.

3. The model can be used to observe the effects of several independent or interactive parameters that are continuous or discrete.

4. A regression technique is better than nonparametric hypothesis testing, which does not yield quantitative relationships between the probability in question and the values of independent variables.

The primary disadvantages of a logistic regression model are:

1. For the basic models, the dependent variable (R) must be a monotonic function of the independent variables. This limitation can sometimes be overcome by employing appropriate variable transforms.

2. The computational effort is substantial, requiring use of relatively powerful computer resources. Until recently, a mini-mainframe computer (in the case of A&T's LOGODDS, a VAX 11/780) was required to perform the necessary calculations efficiently.

With the advent of more powerful desktop computers has come the capability to use them to perform multivariate logistic regression analyses on large data sets. The NVG detection data were analyzed on a Macintosh IIcx desktop computer using LOGIT. The LOGIT software (reference 13) uses the maximum log-likelihood method to fit a logistic curve to response data that can be broken down into discrete categories. As with LOGODDS, the influence of various independent explanatory variables on a discrete-choice response can be determined using the LOGIT module. The significance of these explanatory variables as predictors of the response can be evaluated using the output t-statistics. This process is equivalent to A&T's LOGODDS software, but allows for more than a binary (2-choice) response variable. When used to analyze a binary response data set, the LOGIT regression equation reduces to the same form as that given above for the LOGODDS model. Reference 14 documents a verification study performed by A&T

that confirms the equivalence of the LOGODDS and LOGIT models for analysis of binary response data from Coast Guard detection performance evaluations.

The LOGIT regression model was used in an iterative fashion with each data set to arrive at a fitting function that contained only those search parameters found to exert statistically-significant influence on the target detection response. These fitting functions were then solved for representative sets of search conditions to generate lateral range curves. From these lateral range curves, NVG sweep widths were computed.

1.4.2.4 Sweep Width Calculations

Sweep width, the measure of search performance used by Coast Guard search planners, was defined conceptually in section 1.4.1. Mathematically, the value of W is determined by computing the area under the lateral range curve. Before NVG sweep widths were computed for this report, the analysis procedure described in section 1.4.2.3 was used with the data set for each SRU/target type combination. This procedure identified search parameters that exerted statistically-significant influence on target detection probability. Histograms and scatterplots depicting the distribution of the significant parameters identified within each data set were then prepared. From these histograms and scatterplots a determination was made as to how the raw experiment data could be sorted into subsets of substantial size. These subsets would reflect distinct sets of search conditions. Lateral range curves and sweep widths were then computed for each data subset.

The preceding analysis procedure and the subsequent process of generating lateral range curves and computing sweep widths is best illustrated by the following example.

STEP 1: Identification of Data Subsets. LOGIT analysis of the data set representing helicopters searching for small boats indicated that, in addition to lateral range, visibility, significant wave height (H_S) and the presence or absence of a visible moon exerted statistically-significant influence on target detection probability. The distribution of the data relative to moon visibility was determined from a simple data sort, rather than a histogram, because this parameter could assume only two values. The distributions of visibility and significant wave height within the data set were then examined by generating histograms depicting values of these variables versus frequency of occurrence. Finally, the combinations of these variables within the data set were depicted by creating scatterplots of the distribution of each variable relative to the

others. These scatterplots, combined with the histogram information, identified three combinations of visibility, significant wave height, and moon visibility that were well-represented in the data set. The first set of search conditions was represented by no visible moon, visibilities of 10 to 15 nmi, and significant wave heights of 1.3 to 2.0 feet. The second set of search conditions was represented by a visible moon, visibilities of 6 to 15 nmi, and significant wave heights of 2.0 to 3.3 feet. The third set of search conditions was represented by no visible moon, visibilities of 6 to 15 nmi, and significant wave heights of 2.3 to 3.3 feet.

STEP 2: Generation of Lateral Range Curves. Three lateral range curve equations were generated by inputting the moon visibility parameters (0 for not visible, 1 for visible) and the mean values of visibility and H_S for each of the three data subsets to the LOGIT-generated expression for target detection probability. The three distinct equations that resulted were then plotted for lateral range values between 0 and 2 nmi. This process yielded three distinct plots of lateral range versus target detection probability; one for each combination of search parameters identified in step 1 above.

STEP 3: Calculation of Sweep Widths. Sweep width values were calculated for each of the three sets of search conditions by integrating the applicable LOGIT expressions for target detection probability over the limits 0 to 2 nmi. The integral of the two-choice LOGIT function given in section 1.4.2.3 is:

$$A = \frac{1}{a_1} \ln \left(1 + e^{a_1 x_1 + c}\right) \Bigg|_{x_1 = 0 \text{ nmi}}^{x_1 = \text{selected lateral range limit}}$$

where

A = area under the LOGIT-fitted curve,

a_1 = value of the lateral range coefficient determined by the LOGIT regression analysis,

x_1 = lateral range, and

c = $a_0 + a_2 x_2 + a_3 x_3 + \ldots + a_n x_n$ for specified values of search parameters $x_2, x_3, \ldots x_n$. In this example $n = 4$ with x_2, x_3, and x_4 representing the specified values of visibility (in nautical miles), H_S (in feet), and moon visibility (0 or 1). The values of a_0, through a_4 would be determined by the LOGIT regression analysis.

Sweep width is defined as two times the value of the area A computed above because searching occurs to both sides of the SRU, thus:

$$W = 2A.$$

The methods illustrated in the example above were used with all the SRU/target type combinations for which values of W were computed in this report. Integration limits were selected to include a lateral range interval from 0 nmi to a value well beyond the limits at which any detections were made during the experiments. These limits varied with SRU/target type combination.

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CHAPTER 2
TEST RESULTS

2.1 INTRODUCTION

This chapter summarizes the results of the NVG data analyses described in chapter 1. Two major discussions of results are presented in this chapter: Section 2.2 provides a quantitative analysis of SRU detection performance against each of the target types tested and section 2.3 provides an evaluation of human factors studied during the NVG experiments.

During the 4 NVG experiments conducted to date a total of 1,355 target detection opportunities have been generated for the 5 target types being evaluated in this report. Table 2-1 summarizes the distribution of these detection opportunities by SRU type and target type. Sufficient data were collected in six of the ten SRU/target type categories listed in table 2-1 to support a detailed analysis using the methods described in chapter 1. Of these six data subsets, five will be analyzed in detail in this report because significant new data were added during the spring 1990 experiment. These five data subsets are denoted by an asterisk (*) in table 2-1. The UTB/small boat target data will not be discussed in this report because only one new detection opportunity has been added to that subset since reference 1 was published. This single detection opportunity would not substantially affect the analysis presented in reference 1. Raw data plots only will be presented for the three remaining data subsets.

2.2 DETECTION PERFORMANCE

Sections 2.2.1 and 2.2.2 present discussions and, where appropriate, detailed analyses of each data subset listed in table 2-1. Lateral range curve fits and sweep width estimates are provided for statistically-significant search parameter combinations that are well-represented in the raw data. Lateral range and the presence or absence of a visible moon were identified as significant search parameters for most of the SRU/target type combinations that have been analyzed in detail. Where other search parameters were also found to be significant, some of the available detection

Table 2-1. Numbers of Target Detection Opportunities by SRU Type and Target Type

TARGET TYPE	SRU TYPE	
	Helicopter	UTB
18- and 21-foot Boats	332*	131
4- and 6-person Life Rafts without Retroreflective Tape	282*	198*
4- and 6- person Life Rafts with Retroreflective Tape	55*	10
PIWs with Red Safety Light	232*	25
PIWs with Green Personnel Marker Light	90	No data collected

* to be analyzed in detail in this report

opportunities have not been included in any of the lateral range curve plots because of the data sorting schemes that were employed. These detection opportunities occurred under search conditions that are not yet sufficiently represented within their respective data sets or that have been discussed previously in reference 1.

The lateral range plots depicted in this chapter show lateral range from the SRU along the horizontal axis and target detection probability along the vertical axis. The figures expressed as ratios on the plots represent the number of detections divided by the total number of target detection opportunities occurring within a particular lateral range interval. These ratios correspond to the target detection probability achieved for each lateral range interval. Each plotted probability is denoted by a diamond that is located along the horizontal axis at the average lateral range for all detection opportunities occurring within the applicable lateral range interval. A vertical bar through each diamond denotes the 90-percent confidence limits on the plotted detection probability. Fitted lateral range curves, where included, were generated using the LOGIT regression equation

discussed in chapter 1 with all statistically-significant search variables included. When a data set was found to contain statistically-significant search variables in addition to lateral range, the mean values of these variables were first computed for input to the LOGIT equation. Each data subset plotted represents a unique combination of significant search variable values.

2.2.1 Helicopter Detection Performance

2.2.1.1 PIW Targets With Green Personnel Marker Lights

PIW targets were deployed with Government-issue green PMLs on one night during the spring 1990 experiment. Although the PMLs emit very little light at wavelengths below the ANVIS 625-nanometer cutoff filter (see section 1.3.3), field testing of their detectability by NVGs was considered worthwhile because of their widespread use within the Coast Guard and other segments of the maritime community. Figure 2-1 depicts the raw data for this target type plotted against lateral range. No lateral range curve was fit to the data.

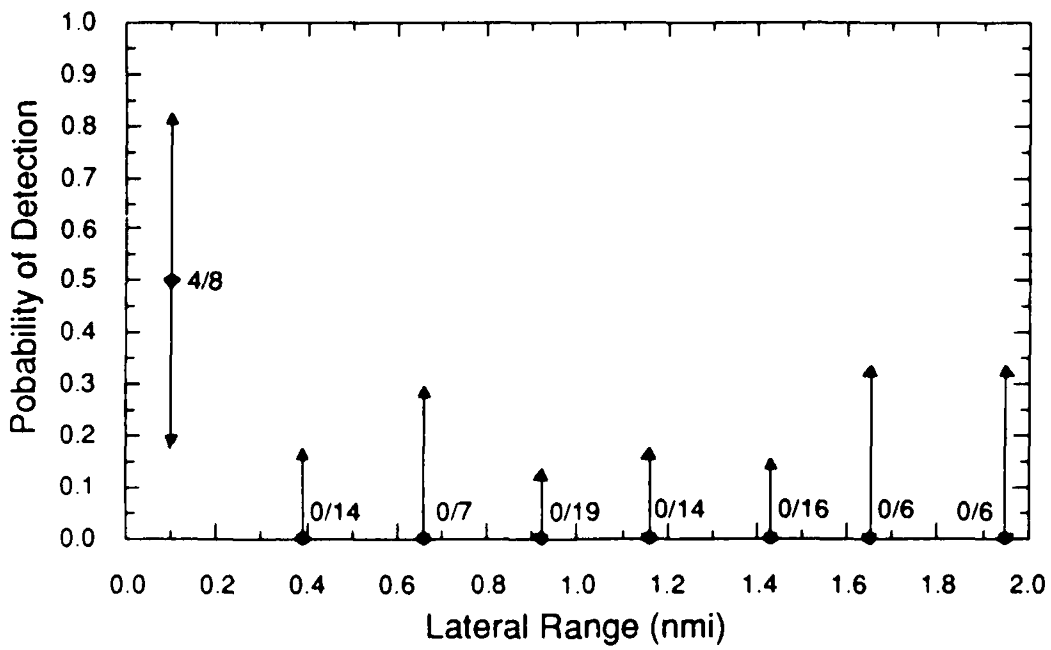

Figure 2-1. Helicopter Detection of PIWs With Gree Personnel Marker Lights (all data)

Of the 90 detection opportunities generated during the helicopter searches that night, only 4 detections were made. None of the detections involved sighting the chemical light itself through the NVGs. One detection was made with the naked eye while a pilot was looking beneath the ANVIS eyepiece to scan flight instruments. The remaining detections involved sighting of retroreflective tape or the PIW's head through the ANVIS. All 4 detections were made at lateral ranges less than 0.25 nmi.

2.2.1.2 PIW Targets With Red Safety Lights

LOGIT regression analysis at the 90-percent confidence level indicated that variation in target detection probability within this data set could best be explained by a combination of lateral range, moon visibility, and the position of artificial light sources (shore lights) relative to the SRU and the target. Shore light position was initially expressed within the raw data set as a three-level categorization of the azimuth location of artificial light sources relative to the line-of-sight between the SRU and the target at either the time of detection (for targets that were detected) or the time of closest point approach (for targets that were missed). The reader will recall from chapter 1 that artificial light azimuth was characterized as "looking toward (1)," "looking across (0)," or "looking away from (-1)" the primary source of shore lights for each detection opportunity.

Based on an initial LOGIT analysis, the raw data were first sorted into two subsets according to the presence or absence of a visible moon. This procedure indicated that 45 detection opportunities occurred in moonlit conditions while 187 opportunities occurred under moonless conditions. From this information, it was decided that no further subdivision of the moon-visible data should be made and that the effects of artificial light would be examined only within the larger (moonless) data subset.

Figure 2-2 depicts the raw data for moonlit conditions sorted into eight, 0.25-nmi lateral range bins. The LOGIT-fitted lateral range curve for this data subset is also plotted in figure 2-2. The lateral range curve was produced by solving the LOGIT regression model equation using the moon-visible condition and the average value of the artificial light parameter as inputs. A sweep width estimate of 0.30 nmi was obtained by integrating the fitted LOGIT probability equation over the limits of 0 to 2 nmi.

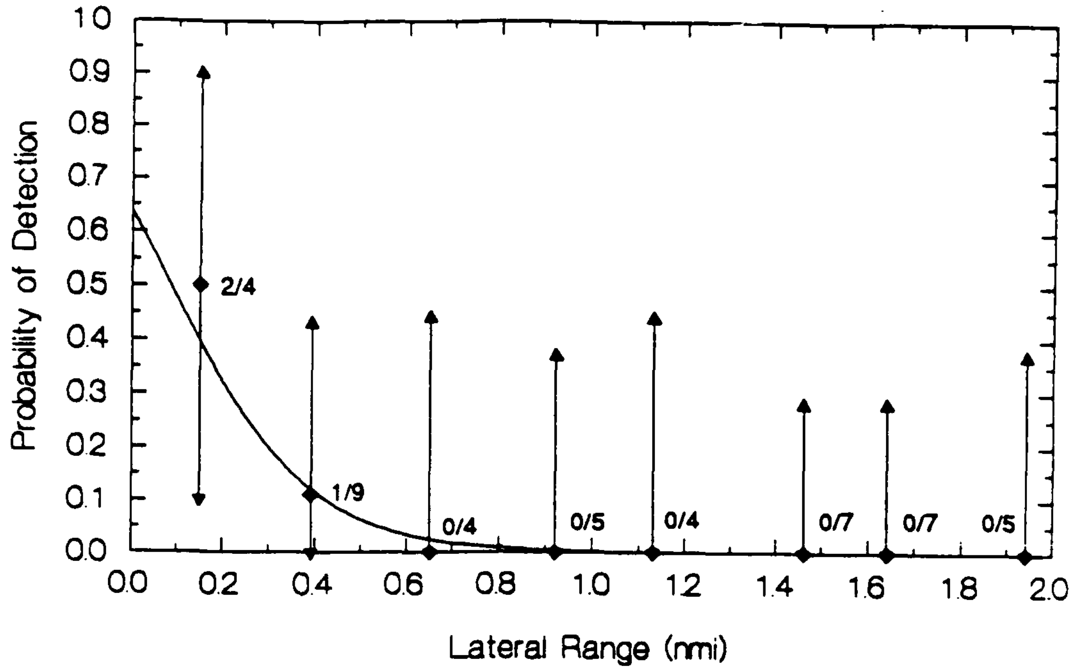

Figure 2-2. Helicopter Detection of PIWs With Red Safety Lights (moon visible)

The data collected in moonless conditions were first sorted into three subsets based on the artificial light parameter value (-1, 0, or 1). Analysis of these three data groups indicated that it was appropriate to combine the "across-light" and "away from light" data into a single subset, since detection performance was similar for both conditions. This combined data subset was sorted into eight, 0.25-nmi lateral range bins and plotted in figure 2-3. The "toward-light" data subset was sorted in like fashion and is plotted in figure 2-4. The LOGIT probability equation (which utilized a 2-level artificial light descriptor: 0 for "across" or "away" and 1 for "toward") was fitted to the data. The lateral range curves plotted in figures 2-3 and 2-4 were obtained by solving the fitted LOGIT probability equation using the moonless condition and a 1 (figure 2-3) or a 0 (figure 2-4) value of the artificial light parameter as inputs. Sweep width estimates of 0.98 nmi and 1.38 nmi were obtained for the conditions represented in figures 2-3 and 2-4, respectively, by integrating the fitted LOGIT probability equation over the limits of 0 to 2 nmi.

Comparison among the data presented in figures 2-2 through 2-4 indicates that both natural and artificial light had adverse effects on ANVIS detection performance against red safety lights. First, the presence of a visible moon appeared to be extremely detrimental to the helicopter crews' ability to detect the red lights. This result makes sense when one considers that the chemical

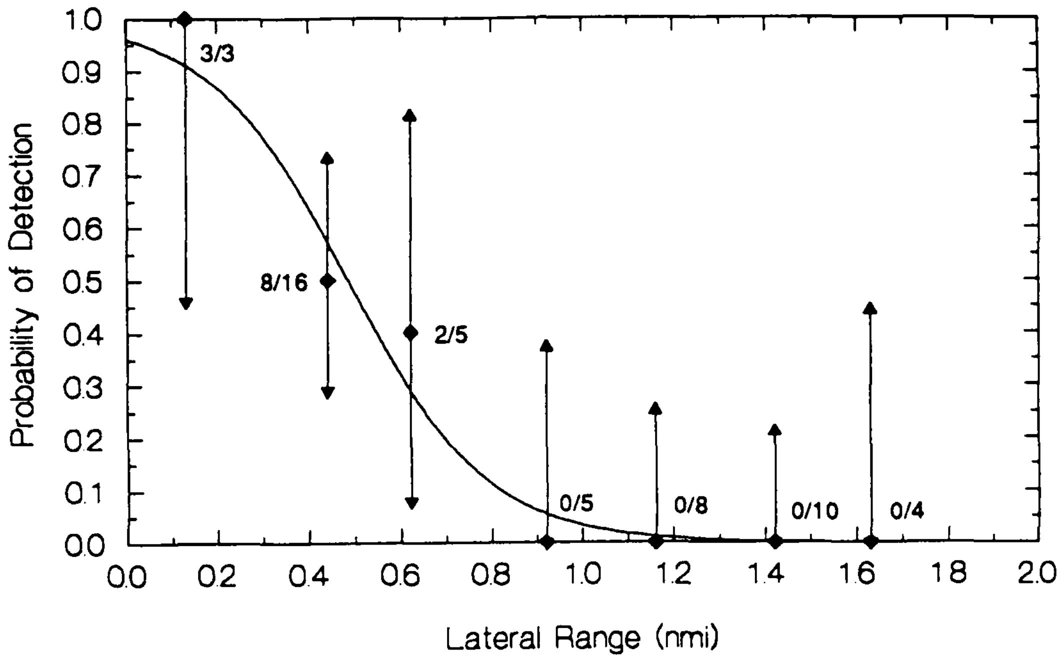

Figure 2-3. Helicopter Detection of PIWs With Red Safety Lights (no moon; looking toward artificial light sources)

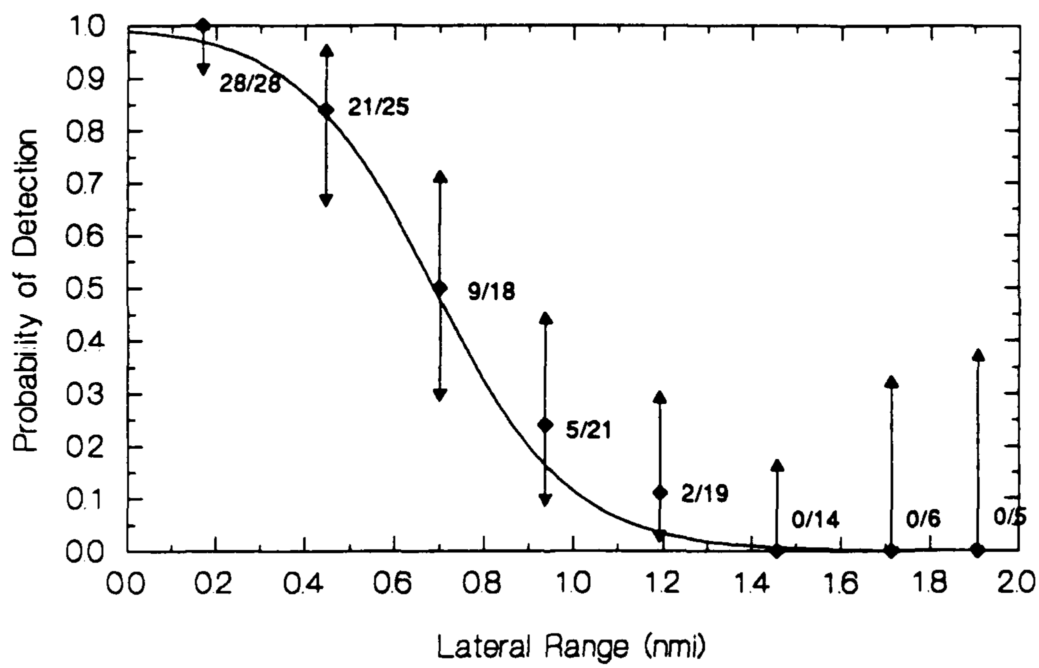

Figure 2-4. Helicopter Detection of PIWs With Red Safety Lights (no moon; looking across or away from artificial light sources)

lights are very low-intensity sources that likely become inconspicuous as moonlight raises the sensitivity threshold of the ANVIS detector tubes. However, the magnitude of the moon's influence on detection performance is very likely overstated in the present data set because of a confounding situation. Only rough sea conditions (H_S from 3.6 to 4.3 feet) are represented in the moon-visible data subset. The moonless data subset contains a greater variety of sea conditions (H_S from 2.0 to 3.9 feet). The LOGIT regression analysis was unable to discriminate between the effects of moonlight and sea conditions at the 90-percent confidence level because of the confounded data. It is very possible that, if additional data were collected in moonlit, calm-sea conditions, the H_S and/or whitecap parameters would also be included in the fitted LOGIT probability equation at the 90-percent confidence level. Second, the data collected in moonless conditions indicate that the aircrews experienced more difficulty in detecting the red safety lights against a lighted shoreline than against a dark or semi-dark sea/sky background. This also agrees with common-sense expectations.

2.2.1.3 Life Raft Targets Without Retroreflective Tape

Thirty-three new target detection opportunities were added to the data set collected in 1989 for this SRU/target combination. Thirty-two of these new detection opportunities occurred in moonlit conditions. LOGIT regression analysis at the 90-percent confidence level indicated that variation in target detection probability within this data set could best be explained by a combination of the lateral range and moon visibility parameters. In reference 1, only lateral range was reported to exert a statistically-significant influence on target detection probability within the 1989 data set. The emergence of moon visibility as a significant parameter is a result of the substantial amount of moonlit data added by the spring 1990 experiment and the associated higher detection probability achieved under those conditions.

After LOGIT analysis, the 282 detection opportunities in this data set were first sorted into 2 levels of moon visibility (0 = not visible, 1 = visible). The initial data sort resulted in a group of 57 detection opportunities under moonlit conditions and 225 detection opportunities under moonless conditions. These data sets were then sorted into eight, 0.25-nmi lateral range bins from 0.0 nmi through 2.0 nmi to produce the raw data points plotted in figures 2-5 and 2-6. Inspection of figure 2-5 indicates that additional data for the moonlit condition are required to provide higher confidence in this analysis and to better-quantify the improved probability of detection achieved in moonlit conditions at lateral ranges out to 1.0 nmi.

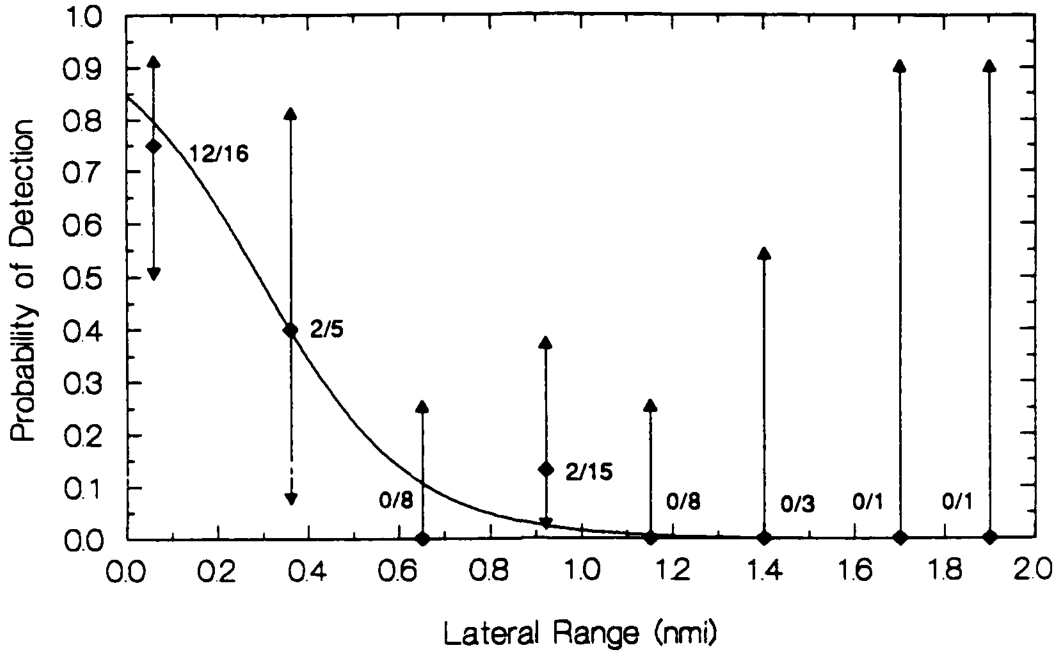

Figure 2-5. Helicopter Detection of Life Rafts Without Retroreflective Tape (moon visible)

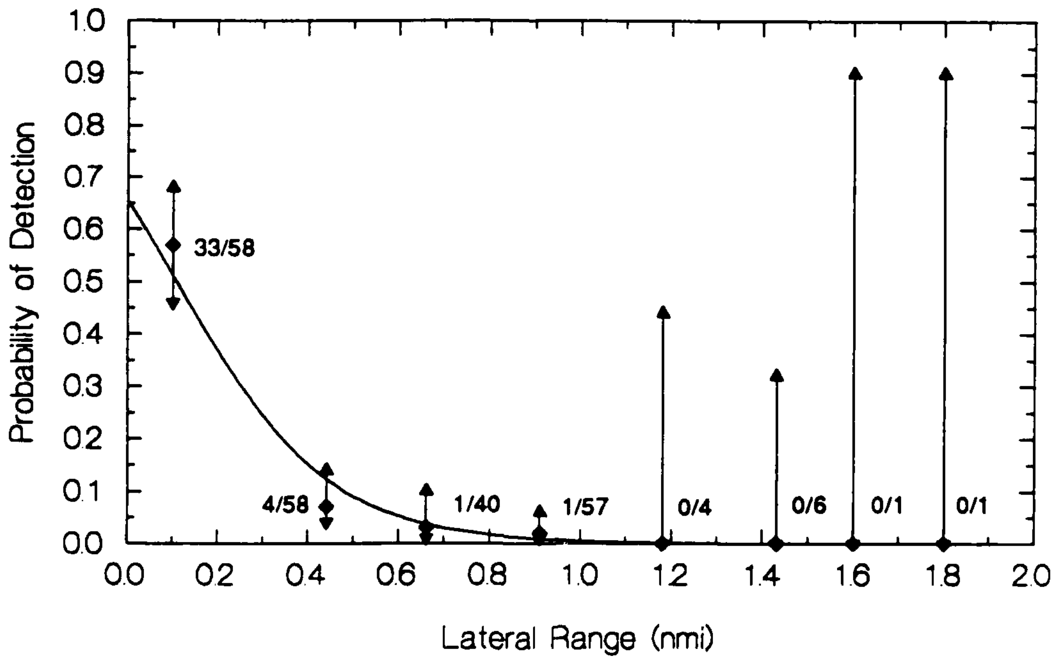

Figure 2-6. Helicopter Detection of Life Rafts Without Retroreflective Tape (moon not visible)

The LOGIT-fitted lateral range curves shown in figures 2-5 and 2-6 were produced by solving the LOGIT regression model equation for the moonlit and moonless conditions, respectively, and for lateral ranges from 0 to 2.0 nmi. Sweep width estimates of 0.46 and 0.24 nmi, respectively, were obtained by integrating the fitted LOGIT probability equation over the limits of 0 to 2 nmi.

2.2.1.4 Life Raft Targets With Retroreflective Tape

LOGIT regression analysis of this relatively small data set indicated that variation in target detection probability was adequately explained at the 90-percent confidence level by the lateral range parameter alone.

Figure 2-7 provides a raw data plot and LOGIT-fitted lateral range curve for the entire data set. The raw data were sorted into four, 0.25 nmi lateral range bins from 0.0 to 1.0 nmi (figure 2-7 is plotted on a 2-nmi lateral range scale to facilitate direct comparison with data for life raft targets without retroreflective tape.) A comparison of figure 2-7 with figures 2-5 and 2-6 reveals the increased probability of detection achieved when retroreflective tape is added to life raft targets. A sweep width estimate of 1.08 nmi was obtained by integrating the fitted LOGIT probability equation over the limits of 0 to 2 nmi.

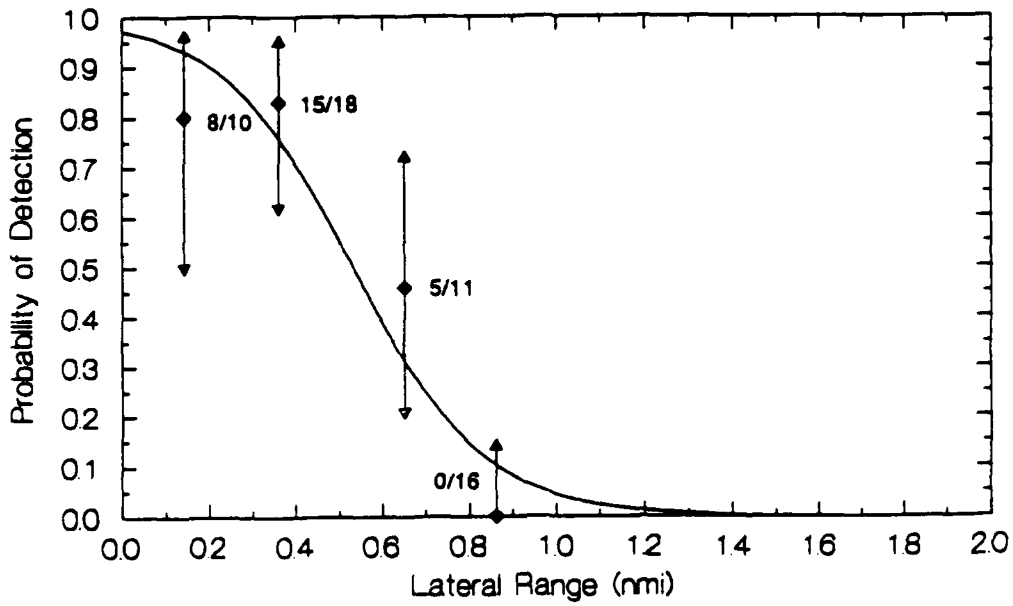

Figure 2-7. Helicopter Detection of Life Rafts With Retroreflective Tape (all data)

2.2.1.5 Small Boat Targets

LOGIT regression analysis at the 90-percent confidence level indicated that variations in target detection probability within the helicopter/small boat data set could best be explained by a combination of the lateral range, significant wave height (H_S), visibility, and moon visibility parameters. Of the 332 detection opportunities in this data set, only 44 were collected during the spring 1990 experiment. The analysis of 1989 data presented in reference 1 identified the same four significant parameters listed above. A total of six data subsets were identified in reference 1 as representing distinct sets of search conditions. Forty-one of the 44 new detection opportunities fall into the second of these 6 data subsets which was defined by moonlit conditions, H_S from 2.0 to 3.3 feet, and visibility from 6 to 15 nmi. The remaining 3 detection opportunities fall into the third of 6 data subsets, which was defined by moonless conditions, H_S from 2.3 to 3.3 feet, and visibility from 6 to 15 nmi.

Figures 2-8 and 2-9 show the updated raw data plots for these two sets of search conditions. The raw data were sorted into eight, 0.25-nmi lateral range bins from 0 to 2 nmi. The LOGIT-fitted lateral range curves plotted in figures 2-8 and 2-9 were produced by solving an updated LOGIT regression model equation using the applicable moon condition, the average values of H_S and visibility, and lateral range values from 0 to 2 nmi as inputs. Sweep width estimates were obtained by integrating the fitted LOGIT probability equations over the limits of 0 to 2 nmi. The resultant sweep width estimates were 1.10 nmi for figure 2-8 and 0.64 nmi for figure 2-9.

2.2.2 UTB Detection Performance

2.2.2.1 PIW Targets With Red Safety Lights

Only 25 detection opportunities were obtained for this SRU/target type combination. Most of the data were collected in moderate seas (H_S from 2.0 to 3.6 feet). The raw data were sorted into four, 0.25-nmi lateral range bins from 0 to 1 nmi. These data are plotted in figure 2-10. A LOGIT regression analysis was not performed because of the small size of the data set. No sweep width estimate was computed pending additional data collection.

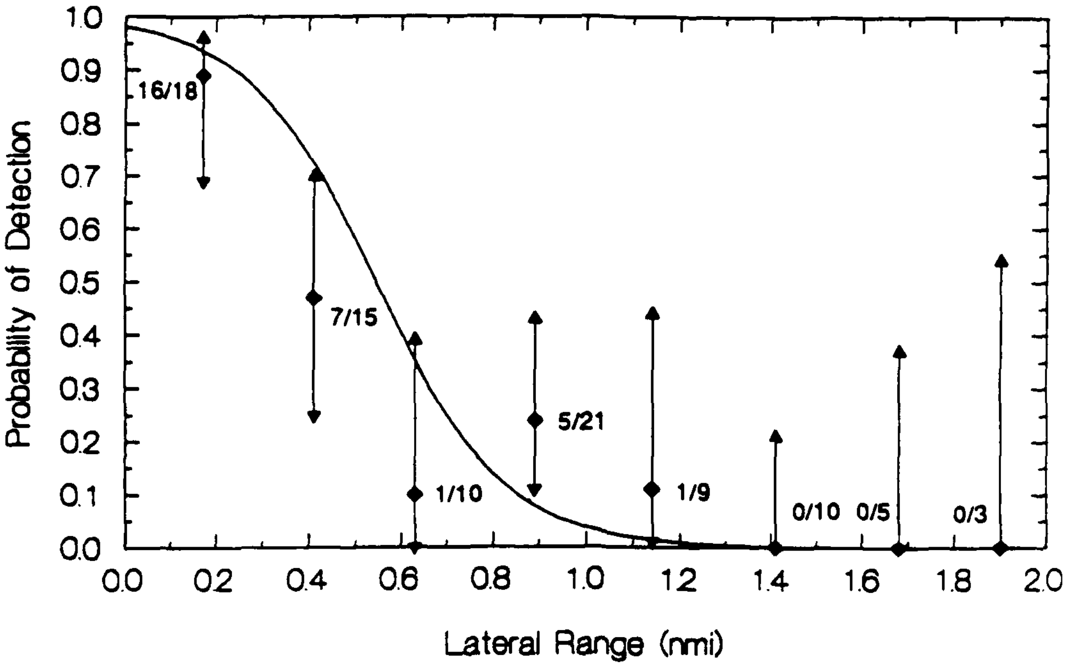

Figure 2-8. Helicopter Detection of 18- and 21-foot Boats
(H_S = 2.0 to 3.3 feet, visibility = 6 to 15 nmi, moon visible)

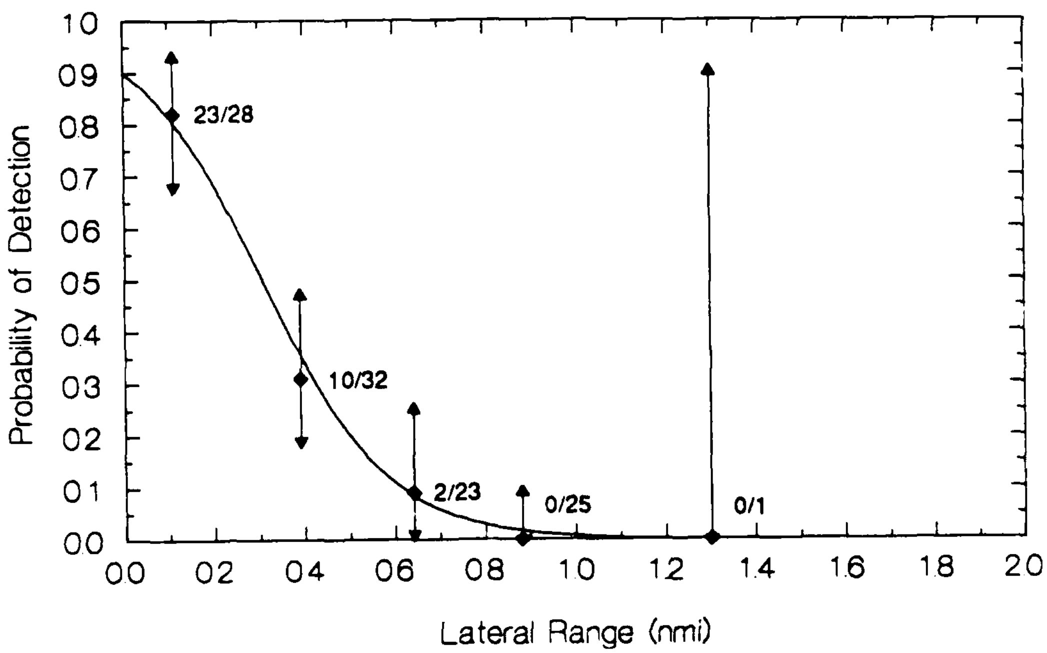

Figure 2-9. Helicopter Detection of 18- and 21-foot Boats
(H_S = 2.3 to 3.3 feet, visibility = 6 to 15 nmi, moon not visible)

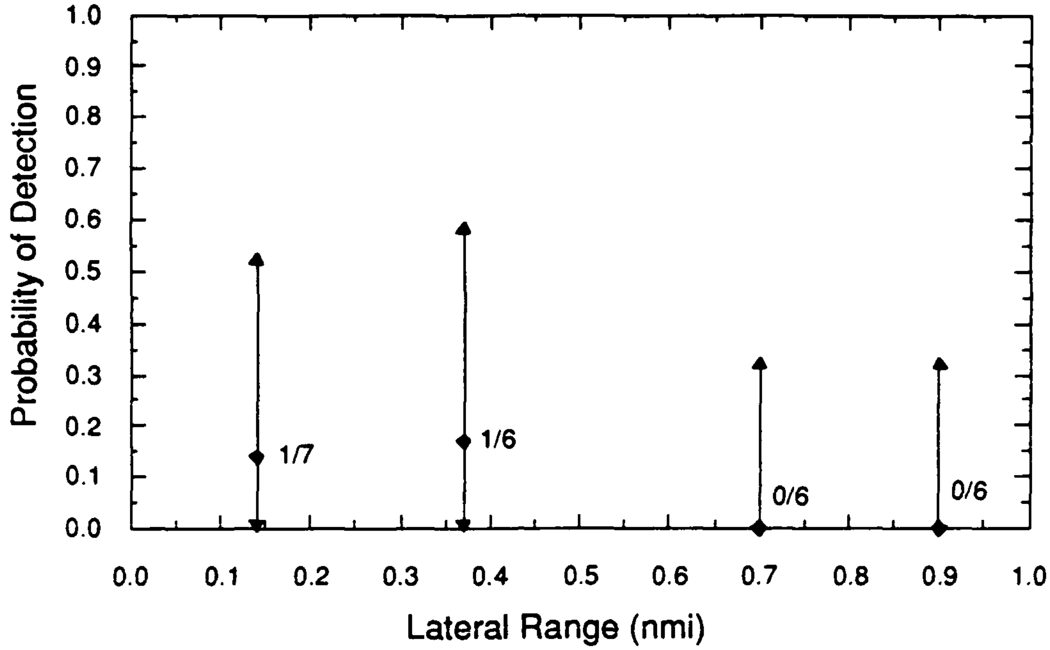

Figure 2-10. UTB Detection of PIWs Targets With Red Safety Lights (all data)

2.2.2.2 Life Raft Targets Without Retroreflective Tape

Eight new target detection opportunities were added to this data set during the spring 1990 experiment. All eight opportunities occurred in moonlit conditions. LOGIT regression analysis of the updated data set at the 90-percent confidence level indicated that variation in target detection probability could best be explained by a combination of the moon visibility and lateral range parameters. The analysis presented in reference 1 identified only lateral range as a significant parameter, however, addition of even the small amount of spring 1990 data proved to be sufficient in this case to identify moon visibility as an additional significant variable. This result brings to four the number of SRU/target type pairs for which moon visibility has been identified as exerting significant influence on target detection probability.

Figures 2-11 and 2-12 provide raw data plots and LOGIT-fitted lateral range curves for the moonlit and moonless search conditions, respectively. The raw data plots were generated by sorting the detection opportunities into four, 0.25-nmi lateral range bins from 0 to 1 nmi. The fitted lateral range curves were produced by solving the LOGIT regression model equation using the appropriate value of the moon visibility parameter and lateral ranges from 0 to 1 nmi as inputs.

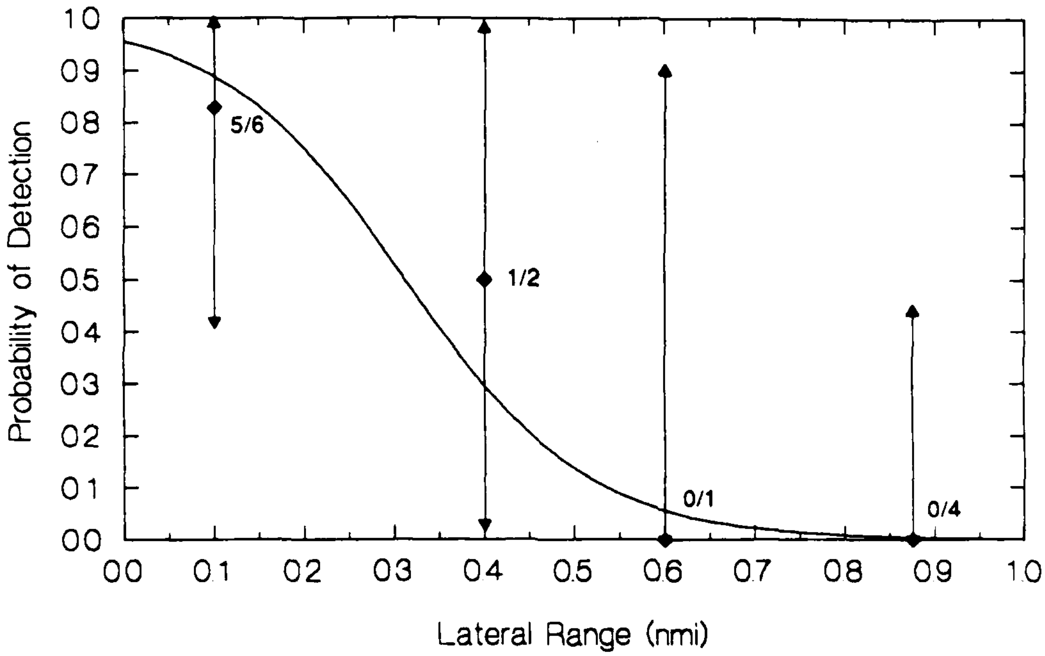

Figure 2-11. UTB Detection of Life Rafts Without Retroreflective Tape (moon visible)

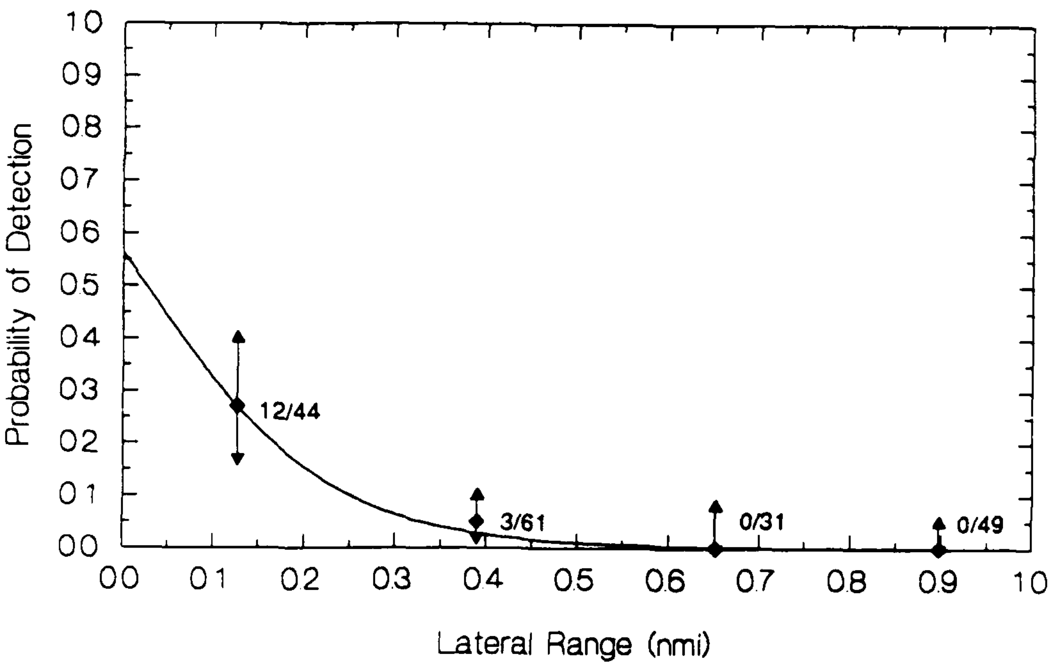

Figure 2-12. UTB Detection of Life Rafts Without Retroreflective Tape (moon not visible)

Sweep width estimates were obtained by integrating the fitted LOGIT probability equation over the limits of 0 to 1 nmi. The resultant sweep width estimates were 0.64 nmi for figure 2-11 and 0.16 nmi for figure 2-12. The reader is cautioned that, because only 13 detection opportunities exist for the moonlit condition, the lateral range curve and sweep width estimate given for the data in figure 2-11 should be considered as preliminary in nature.

2.2.2.3 Life Raft Targets With Retroreflective Tape

Only 10 target detection opportunities were obtained for this SRU/target type combination. These data were collected in relatively rough sea conditions (H_S from 3.5 to 4.3 feet) on a single night of the spring 1990 experiment.

The raw data were sorted into two, 0.5-nmi lateral range bins from 0 to 1 nmi. These data are plotted in figure 2-13. No LOGIT regression analysis was performed and no sweep width estimate was computed due to the small size of the data set. More data are required to evaluate the impact on UTB detection performance of adding retroreflective tape to life rafts.

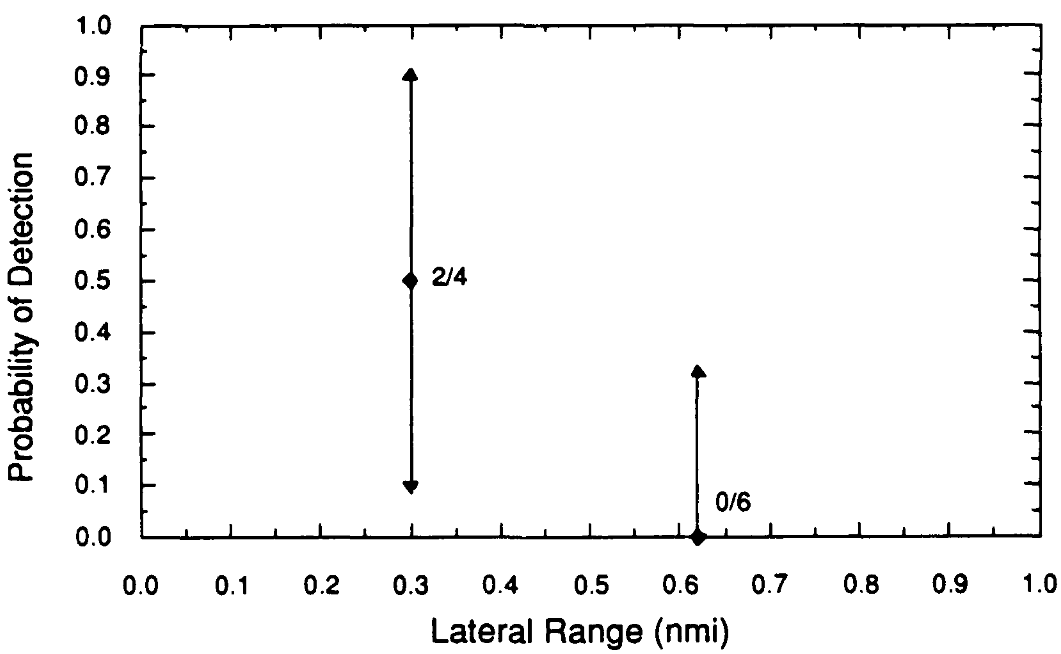

Figure 2-13. UTB Detection of Life Rafts With Retroreflective Tape

2.3 HUMAN FACTORS

The next three sections provide information that relates to the human factors aspects of conducting NVG-assisted searches in the marine environment. Section 2.3.1 provides quantitative data on where and from what crew positions NVG detections were made. Sections 2.3.2 and 2.3.3 summarize subjective comments and observations made by the SRU crews and members of the R&D Center test team.

2.3.1 Analysis of Detection by Position

Figure 2-14 depicts the distribution of target detections by helicopter SRUs. This information is provided by target type in the first four diagram pairs and for all helicopter detections combined in the fifth diagram pair. The circular diagrams on the left side of figure 2-14 show the distribution of initial target detections as a function of relative bearing (expressed in "clock" format). This information is independent of which crew position actually made the detection. The silhouette diagrams on the right side of figure 2-14 show the distribution of initial target detections as a function of the five crew positions onboard the HH-3 and CH-3 helicopters. The information in the silhouette diagrams is independent of the clock bearings at which the targets were initially sighted.

The information in figure 2-14 shows that the copilot position (left seat) made more detections than the pilot position (right seat) for all data sets. This occurred even though the two pilots usually switched seats between sorties or on alternate nights. The difference in the number of detections made by the two pilot positions is consistent across all four target types, and suggests a degradation in search capability that results from constant scan-shifting by the pilot between NVGs outside the cockpit and unaided vision inside the cockpit. This difference in detection performance might have been more pronounced except that during many searches, the aircraft was flown from the copilot seat for significant periods of time.

In the aft section of the helicopter, the flight engineer, who usually searches through an open door with a wide field of view and no glass to reflect light, made more detections overall than either the rescue swimmer position or the avionics position. The rescue swimmer position, which was not equipped with a seat on two of the four test helicopters, made substantially fewer initial detections than any other crew position. The swimmer confirmed many detections, but was first to see only those 20 listed.

The clock-bearing data in figure 2-14 indicate that most helicopter detections were made between 9 and 11 o'clock on the port side and between 1 and 3 o'clock on the starboard side. A pronounced dip in detections consistently occurred dead-ahead of the aircraft.

Figure 2-15 depicts the distribution of detections for UTB SRUs. Unlike the helicopters, not all crew positions depicted on the UTB silhouette diagrams were always manned. The UTBs typically searched with two NVG-equipped lookouts who positioned themselves on the port and starboard bow when seas were calm and the weather was warm. When spray and/or cold wind was prevalent, the lookouts took shelter behind the wheelhouse at the port and starboard aft positions. The forward and aft center positions were seldom manned unless three or more NVG-equipped lookouts were available or only a single lookout was searching with NVG. All helm detections were made with the naked eye.

The clock-bearing data in figure 2-15 indicate that most UTB detections were made between 9 and 10 o'clock on the port side and between 2 and 3 o'clock on the starboard side. A comparison of the composite clock bearing and silhouette data indicates that the starboard aft lookouts made more detections than the port aft lookouts. This may be because the cabin door is directly adjacent to the port aft lookout position. The open door may have allowed more light to interfere with NVG operation and more distraction of the port aft lookout due to conversations with personnel inside the wheelhouse.

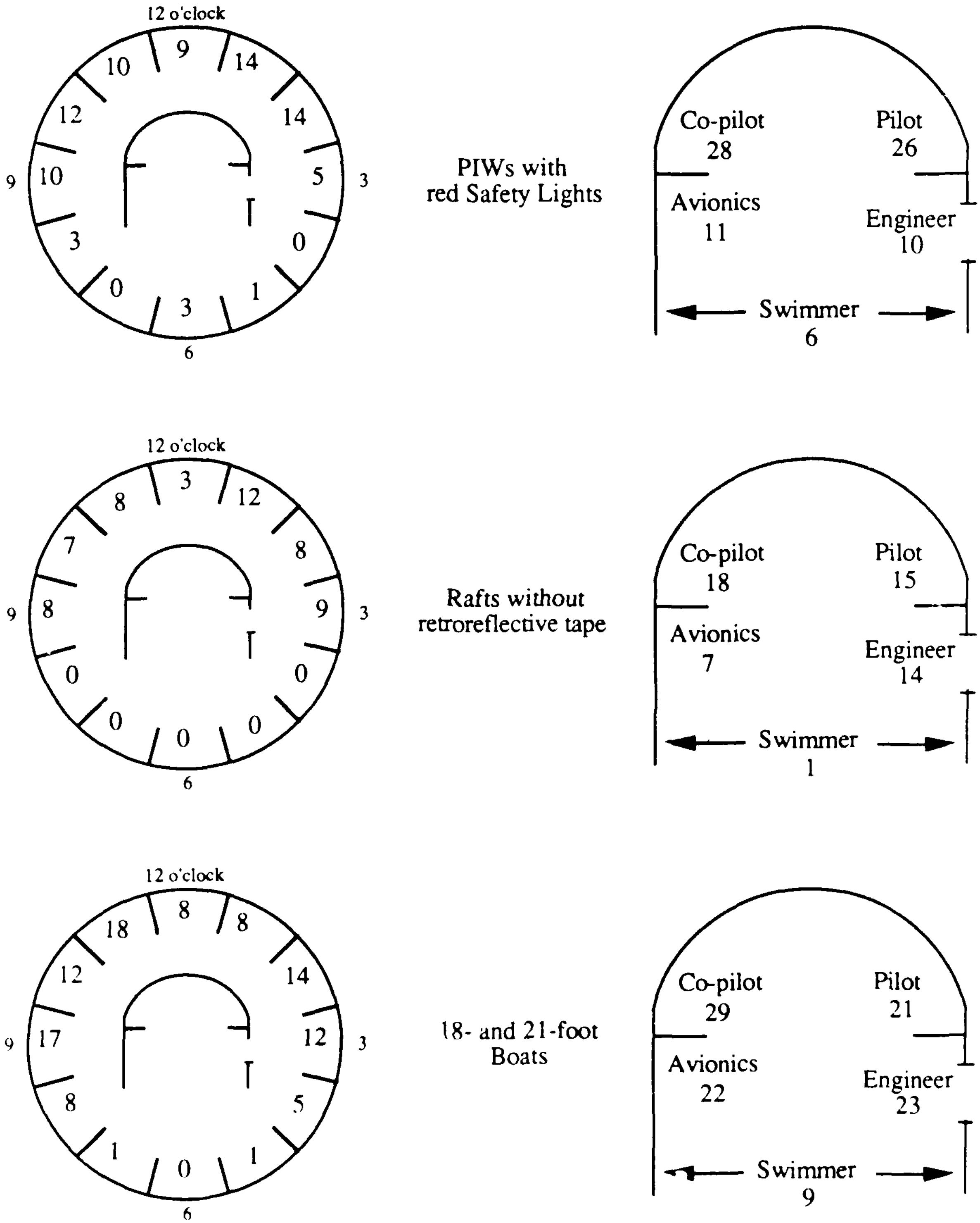

Figure 2-14. Distribution of Helicopter Detections by Clock Bearing and Crew Position
(Sheet 1 of 2)

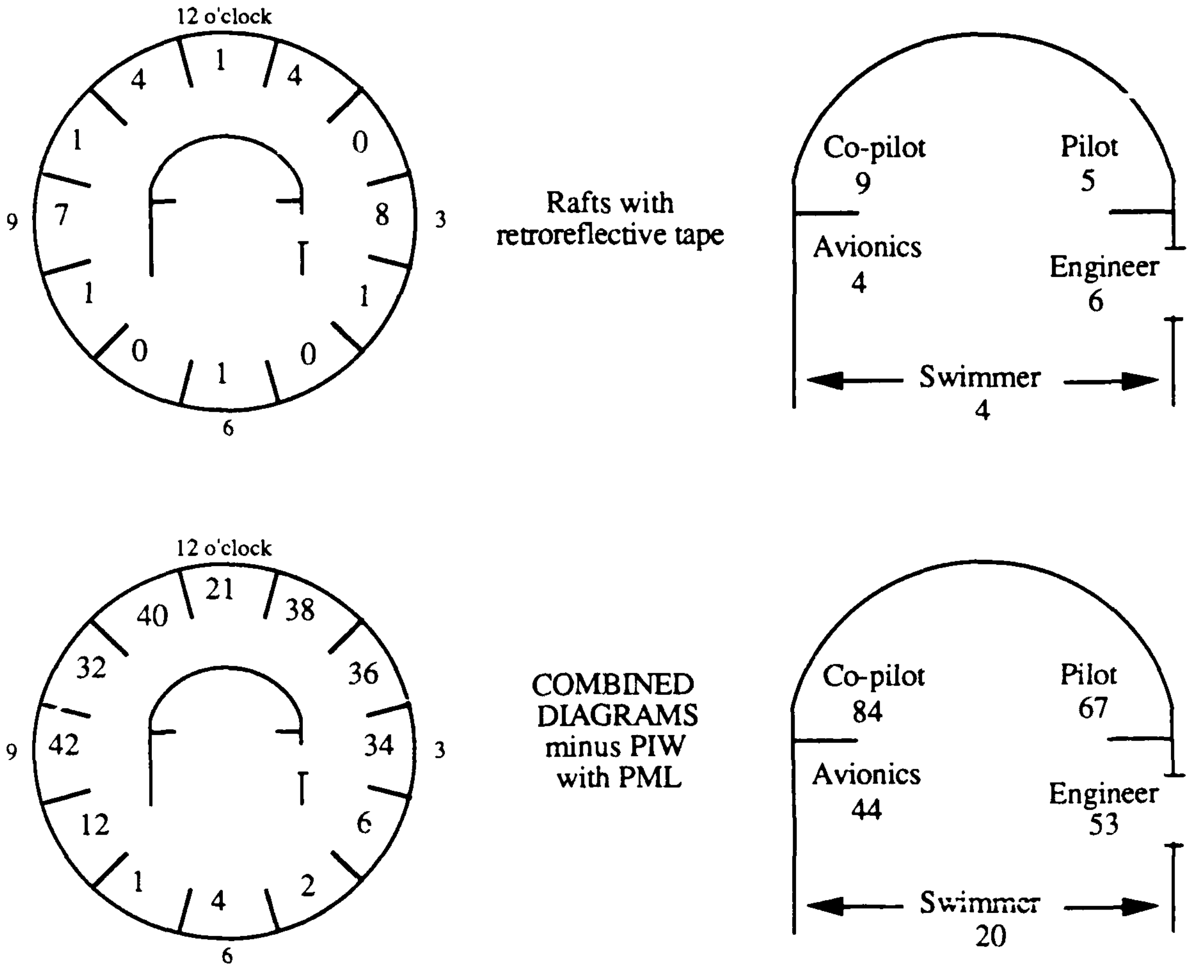

Figure 2-14. Distribution of Helicopter Detections by Clock Bearing and Crew Position
(Sheet 2 of 2)

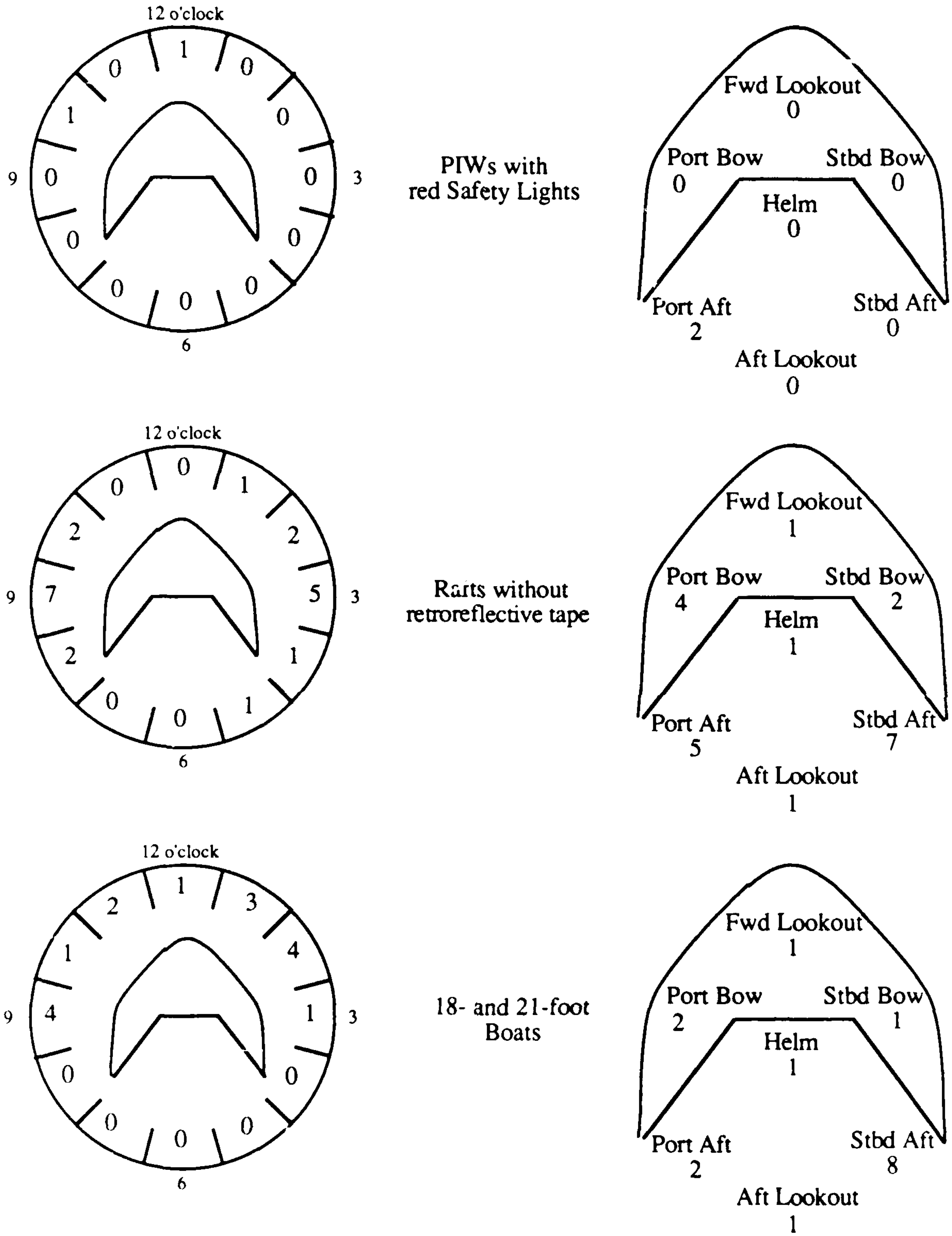

Figure 2-15. Distribution of UTB Detections by Clock Bearing and Crew Position

(Sheet 1 of 2)

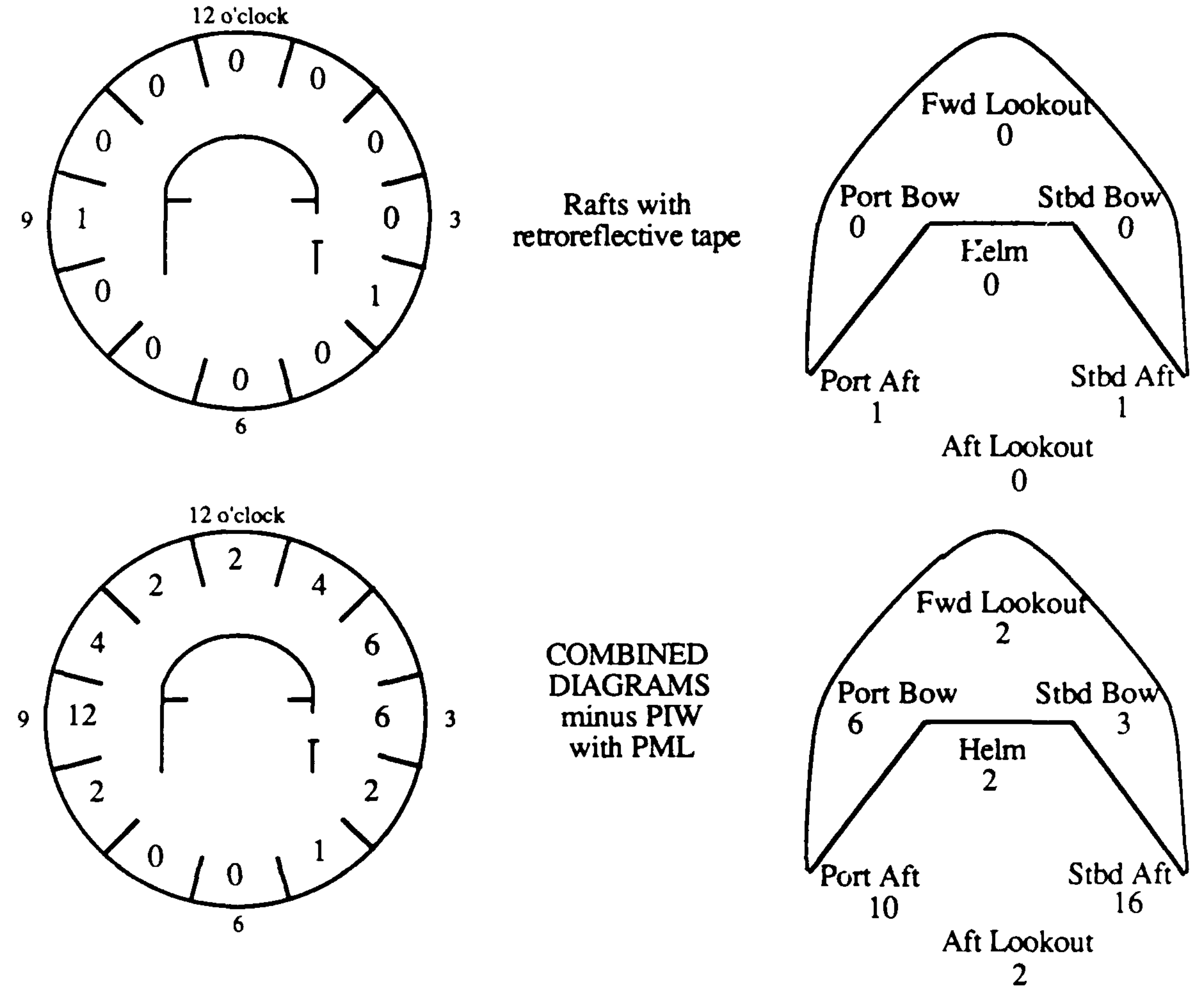

Figure 2-15. Distribution of UTB Detections by Clock Bearing and Crew Position
(Sheet 2 of 2)

2.3.2 SRU Crew Comments Concerning NVG Use and Target Appearance

Subjective comments from the SRU crews concerning the comfort, ease-of-use, and effectiveness of the NVGs and their suitability for Coast Guard SAR operations were solicited each night by the data recorders. References 6 through 8 contain verbatim lists of the comments received during the four NVG experiments conducted to date. A condensed summation of these comments is provided below.

Helicopter Crews

1. A low moon inhibited the lookouts' ability to detect small targets much like the sun does during daylight searches. Even a partial moon is a blinding light source when viewed through the NVGs.

2. NVGs appeared to perform better when looking toward shore except against targets equipped with lights.

3. Light sources, either from inside the helicopter, an overhead moon, or shore lights shining through a window or door on the other side of the aircraft, created glare on the inside surfaces of the window glass. Perhaps the inside surfaces of the windows should be coated with anti-glare materials much like the outside of the windows.

4. In periods of low ambient light, there was difficulty seeing outside the helicopter. The NVG display was black or grainy and the instruments created too much glare on the windows. Also, outside the aircraft, the rotating beacon became more visible. This was more of a problem in fog or haze than on clear nights. On a clear night, the rotating beacon or search light can help illuminate targets.

5. Complaints of eye strain were common, especially after long sorties. Even 5-minute breaks seemed to help. Also, as the searches progressed, crews reported that goggle focus appeared to wander. After several hours, many crewmembers reported being unable to bring the NVGs back into focus.

6. Crews that were given the opportunity to view a target with the NVGs before commencing searches felt that it was helpful in familiarizing them with what to look for.

7. Some crews felt that it was helpful to fly near the shoreline and refocus the NVGs between searches.

8. One crew felt that a counterweight is needed on the back of the helmet to offset the goggle weight. The battery pack that now exists does not provide the appropriate weight.

9. Crews reported that red Safety Lights were very easy to see except when looking towards the shore. Later in the search they reported the lights were dimming. (It is unclear whether this is because the moon came up or the lights became noticeably dimmer.)

10. Rough seas make it difficult to pick targets out from waves/white caps.

<u>UTB Crews</u>

1. Goggles were easier to focus in good light conditions, the visual presentation was better, and it was easier to maintain concentration. Lookouts found that, in lower light levels, concentrating on whitecaps helped keep them from simply staring at the display lens.

2. Coxswains and helmsmen preferred not using NVGs because they felt it interfered with their job of navigating the boat. Some coxswains felt that keeping a pair of NVGs at hand to check lookout reports was a good idea while others felt that the goggles didn't provide any more information than radar.

3. There were many variations of "my eyes are tired." Typically after an hour, lookouts reported tired/sore/watery eyes and after about two hours, they reported headaches and disorientation. Short breaks and lookout rotation appeared to help alleviate some of these problems.

4. Some lookouts, even those not normally prone to it, became seasick very easily while using NVGs. This occurred more often as seas became rougher and occasionally UTBs returned to port because of crew seasickness.

5. There were many complaints that the PVS-5 and PVS-7 head gear was very uncomfortable and that the goggles pressed on the face, but later in the searches, there were fewer complaints of this nature. Some crews chose not to wear the headset and held the goggles as they would binoculars.

6. Looking at brighter shore lights reduced the effectiveness of the goggles. Often these lights would obscure up to half the distance from the horizon.

7. When sea conditions and sea spray forced lookouts behind the pilot house, the intensity of the running lights or stern light and their glare obscured or partially obscured the view through the NVGs. This left a fairly narrow sector abeam for effective searching. One crew secured the running lights and eliminated this problem.

8. Lighted objects could be easily seen on clear nights even when not visible to the naked eye.

9. Crews that were given the opportunity to view a target with the NVG before commencing searches felt that it helped them by familiarizing them with what to look for.

10. Plenty of lens cleaning paper was needed when spray or precipitation was present. Frequent breaks should be taken to rest eyes and clean lenses.

11. Some coxswains felt what was really needed was a better radar.

SRU crewmembers were also encouraged to provide descriptions of target appearance when detections were made. These target descriptions are listed in table 2-2 by SRU and target type. The descriptions appear in the table in descending order of frequency for each SRU/target type combination.

Table 2-2. Summary of Target Appearance Descriptions

TARGET DESCRIPTIONS	SEARCH UNIT TYPE	
	HELICOPTER	UTB
Boats	Boat/Skiff Bright/white/light Open white boat Black/dark/dark w/canvas Boat w/ canvas White w/ dark bottom	Bright/white/light Boat/skiff Black/dark Boat w/canvas Could not tell/something Greenish Dingy capsized
Rafts without retroreflective tape	Raft Bright/white/light Light w/ dark bottom Black/dark w/white top Black w/white reflection off anti-collision light	Raft Black Light w/dark bottom Bright/white/light blob Round - grey black
Rafts with retroreflective tape	Flashing with aircraft beacon Raft with tape White doughnut Flashing triangle Glowing object	Raft with tape, bright top Top of a raft
PIW with PML	Retroreflective tape, no chem light Target, saw chem light under goggles first Two reflective balls	None
PIW with red Safety Light	Dim steady glowing light Light in the water Bobbing A little light A chem light Blinking light Very bright light	Dim light

2.3.3 Test Team Observations Concerning NVG Use

Data recorders who accompanied the SRU crews on the NVG searches logged subjective comments as time and opportunity permitted. These comments were sometimes similar in nature to comments received directly from the SRU crews, but were made from a third-party viewpoint while not directly involved in the NVG search task. All data recorders were familiar with NVG characteristics and principles of operation. Some of the data recorders also had at least an hour or two of experience using the NVGs while underway onboard an SRU or a workboat. Data recorder comments are synopsized below.

Helicopter Observations

1. Cockpit workload drew the pilot and/or copilot off NVGs frequently for communications, instrument scans and navigation computer adjustments. These distractions were usually brief, but occurred frequently. Coverage of the search area with NVGs was probably less thorough than with daytime visual search due to this frequent scan shifting without benefit of peripheral vision outside the cockpit.

2. Helicopter crews seemed well trained on NVG use and most maintained good scanning technique until late in the sortie.

3. Helicopter crewmembers, particularly those at the pilot, co-pilot and avionics positions, noticed glare from light shinning off the inside of the windows. Whether the light source was from inside the helicopter, or external light shining into the helicopter, it hampered NVG search efforts.

UTB Observations

1. Weather and sea conditions greatly affected searcher attitudes onboard the UTBs. Moderate sea swell or wind chop and/or poor ambient light brought on frequent instances of seasickness and lack of enthusiasm for NVG use among the crews. Several crews were very positive about NVG testing when calm seas and good ambient light prevailed.

2. UTB crews consistently complained about soreness in their eyes and headaches when using the NVGs and some crews began experimenting with ways of relieving eye strain. These included using the goggles in a hand-held mode and occasionally searching without NVGs, sitting on the deck and supporting the goggles with their hands, laying on the deck, and taking frequent short breaks. These methods appeared to ease crew discomfort somewhat.

3. Some nights, radar detected targets that could be found with a search light, but not with goggles. Even when NVG-equipped lookouts were notified that radar had a target in a certain area, they often were unable to locate it whereas the coxswain using the search light could. (The majority of this type of incident occurred on darker nights when NVG performance was marginal.)

4. Boat crews achieved consistently poorer detection results than did helicopter crews, and this lack of success with the NVGs was reflected in crew attitudes and motivation during the later stages of the experiments.

5. The level of the UTB crews' knowledge and training relative to the use and care of the NVG systems was much more varied than with the helicopter crews.

6. UTB crews would likely benefit from a helmet-mounted NVG arrangement that allows for non-NVG peripheral vision and provides for flipping the goggles up and away from the face while performing engineering checks, navigation chores, radar scans, and other non-search duties.

CHAPTER 3
CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

The following conclusions are based on the quantitative data analyses and subjective comments provided in chapter 2. The conclusions address new findings only. Additional conclusions based on earlier NVG experiments can be found in chapter 3 of reference 1.

3.1.1 Search Performance of NVG-Equipped Helicopters

1. Green personnel marker lights do not appear to enhance the detectability of PIW targets when viewed through ANVIS goggles. No ANVIS detections of the PML lights were achieved during a sortie that presented 90 opportunities for detecting these targets.

2. When the moon is not visible, red Safety Lights significantly enhance the detectability of PIWs when viewed through ANVIS goggles. Detection performance, as measured by sweep width, was two to three times better than that achieved for PIW targets with retroreflective tape alone under these conditions (see reference 1). When the moon was visible, detection performance (as measured by sweep width) was comparable to levels achieved for PIW targets with retroreflective tape alone.

3. When the moon is not visible, looking toward moderate levels of artificial light through the ANVIS goggles appears to diminish the detectability (as measured by sweep width) of red Safety Lights by about 25 percent.

4. More data must be collected under moonlit/calm sea conditions to quantify the effects of sea state on the detectability of PIWs equipped with red Safety Lights.

5. The presence of a visible moon appears to double ANVIS detection performance (as measured by sweep width) against life raft targets without retroreflective tape. Additional data collection under moonlit conditions is necessary to improve confidence in the applicable sweep width value.

6. Analysis of limited data indicates that the addition of retroreflective tape to life rafts in accordance with SOLAS specifications may at least double their detectability (as measured by sweep width) by the ANVIS goggles. Results to date are conservative because they are based on data collected in 3.0- to 4.3-foot seas and primarily moonless conditions.

7. Additional data collected in 1990 indicate that moonlight exerts a somewhat stronger influence on the detectability of white, 18- to 21-foot boats than reported in reference 1. A new sweep width estimate of 1.10 nmi was computed for ANVIS detection of these targets in moderate seas (H_S from 2.0 to 3.3 feet) with good (6- to 15-nmi) visibility and a moonlit sky. The reference 1 sweep width estimate, based on limited data, was 0.88 nmi.

3.1.2 Search Performance of NVG-Equipped UTBs

1. Based on a very limited data set, it appears that UTBs achieve only marginal detection performance against red Safety Lights at lateral ranges less than 0.5 nmi. No detections were achieved at lateral ranges greater than 0.5 nmi.

2. The presence of a visible moon appears to significantly enhance UTB detection performance against life rafts without retroreflective tape. More data must be collected in moonlit conditions to accurately quantify the magnitude of this improvement in detection performance and to develop a reliable sweep width estimate for moonlit conditions.

3.1.3 General Conclusions

1. The presence of a visible moon significantly enhances the ability of NVG-equipped SRUs to detect small search targets that are not equipped with lights.

2. The presence of moonlight or artificial light in the background against which a light-equipped target is viewed will likely diminish the detectability of that target by NVGs.

3.2 RECOMMENDATIONS

The following interim recommendations are added to those already provided in reference 1. These recommendations are based on new information obtained during the spring 1990 NVG test.

Daylight visual sweep widths referenced in sections 3.2.1 and 3.2.2 are tabulated in reference 9. Fatigue, weather, and speed corrections listed in reference 9 are not to be applied unless specified below.

3.2.1 NVG Searches With Helicopters

1. For search planning purposes, PIWs with green PMLs should be treated the same as PIWs without lights when computing sweep width. Consideration should be given to limiting the use of green PMLs as NVG night time searching becomes more common. We would recommend that red chemical safety lights be evaluated.

2. If a PIW is known to be equipped with a functioning red chemical Safety Light, the following sweep width estimates should be used.

   moon visible in search area - use the daylight visual sweep width for PFD-equipped PIWs and search altitudes up to 500 feet. This value is currently 0.4 nmi.

   moon not visible in search area - multiply the daylight visual sweep width specified above by 2.5.

3. The following sweep width estimates should be used when the search object is a 4- or 6-person life raft without retroreflective tape.

moon visible in search area - multiply the daylight visual sweep width, corrected for weather only, by 0.35.

moon not visible in search area - multiply the daylight visual sweep width, corrected for weather only, by 0.2.

4. Pending additional data collection, sweep width for 4- or 6-person life rafts with retroreflective tape applied per SOLAS specifications should be estimated by multiplying the daylight visual sweep width, corrected for weather only, by 0.9.

5. Guidance provided in reference 1 for estimating sweep width for small boat targets is still valid.

3.2.2 NVG Searches With UTBs

1. The following guidelines should be used when estimating sweep width for life raft targets without retroreflective tape.

   moon visible in search area - multiply the daylight visual sweep width, corrected for weather only, by 0.3.

   moon not visible in search area - NVG search by UTBs is not recommended under these conditions.

2. No search planning guidance applicable to UTBs searching for red Safety Lights or 4- and 6- person life rafts with retroreflective tape can be made until additional data are collected.

3.2.3 General Recommendation

When the search object is known to be equipped with a light, search planners should assign NVG search patterns with major legs oriented perpendicular to shore lights if the shore lights are likely to be visible from the SRU.

3.2.4 Recommendations For Future Research

1. More NVG search performance data should be collected in moonlit conditions. Data for clear, calm moonlit conditions are especially lacking in the existing NVG data base.

2. The problem of glare on aircraft window surfaces from light sources both inside and outside the aircraft should be examined. Anti-glare coatings or new window materials should be evaluated.

3. Data collection priorities for future NVG tests are listed below in descending order of preference.

   - 18- and 21-foot boats in moonlit conditions,
   - PIW targets without lights in moonlit conditions,
   - raft targets without retroreflective tape in moonlit conditions,
   - raft targets with retroreflective tape in all search conditions, and
   - red safety lights in moonlit conditions (helicopter) or all conditions (UTB).

4 Larger surface SRUs (such as WPBs and WMECs) should be evaluated for their NVG search performance.

5. UTBs should be evaluated using four NVG lookouts on a 2-on/2-off rotation to alleviate fatigue and seasickness.

6. Sources of NVG-compatible illumination should be evaluated on surface and air SRUs, particularly against targets that are not equipped with lights. These targets should include both retroreflective and non-retroreflective materials.

7. The HH-65A and HH-60J Coast Guard helicopters should be evaluated for their NVG search performance. Onboard the HH-3 and CH-3 helicopters evaluated in this study, the 3 crew positions aft of the cockpit made more than 43 percent of all initial target sightings. Since the HH-65A and HH-60J carry smaller crews, it is possible that their NVG detection performance will not be as good as that reported here. Any performance differences should be identified and quantified to ensure that accurate sweep widths are available for these newer aircraft.

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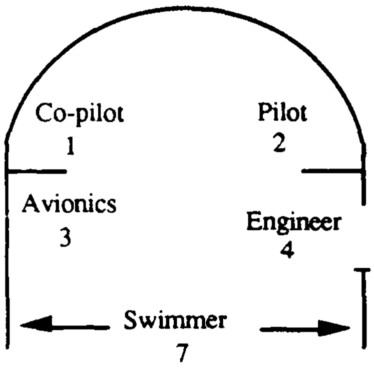
KEY TO DATA APPENDIX

This appendix contains the raw data files for the US Coast Guard Night Vision Goggle experiment conducted in the spring of 1990. Each data file is labeled with the search unit hull number and the date on which the data were collected. The operational Coast Guard units corresponding to each hull number are listed below:

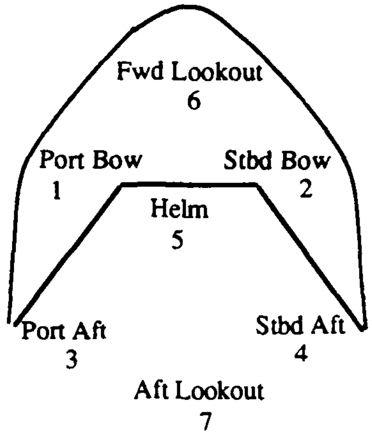
Hull No.	Unit Type	Operational Command
CG-1488	HH-3F	Coast Guard Air Station Cape Cod, MA
CG-41341	41-foot UTB	Coast Guard Station Fort Pierce, FL

The data files are listed in chronological order by unit. Each file record represents one search unit/target interaction and describes the target detection opportunity using 25 parameters of interest. The following is a key to the format of each record.

Item 1:	DET	Detection? (1 = yes, 0 = no)
Item 2:	LATRNG	Lateral range (nautical miles)
Item 3:	TOT	Time on task (hours)
Item 4:	PRECIP	Precipitation level (0 = none, 1 = light, 2 = moderate, 3 = heavy)
Item 5:	VIS	Visibility (nautical miles)
Item 6:	WDSP	Wind speed (knots)
Item 7:	CLDC	Cloud coverage (tenths of sky obscured)
Item 8:	HS	Significant wave height (feet)
Item 9:	WHCAPS	Whitecap coverage (0 = none, 1 = light, 2 = heavy)
Item 10:	SWDIR	Relative wave direction: (1 = looking into oncoming waves, 0 = looking across the direction of wave travel, -1 = looking at the backside of the waves)
Item 11:	RELHM	Relative humidity (percent)
Item 12:	AIRTP	Air temperature (degrees Celsius)
Item 13:	WTTP	Water temperature (degrees Celsius)
Item 14:	RELAZ	Relative azimuth of artificial light (1 = looking into, 0 = looking across, -1 = looking away from)
Item 15:	LEV	Artificial light level (0 = rural, 1 = suburban, 2 = urban)
Item16:	ELEV	Moon elevation (degrees above(+) or below(-) the horizon)
Item 17:	MOONVIS	Moon visible from search unit (1 = yes, 0 = no)
Item 18:	MOONRA	Moon relative azimuth: (1 = looking into, 0 = looking across, -1 = looking away from)
Item 19:	PHS	Moon phase (0 = none, .2, .5, .7, 1 = full)
Item 20:	SPD	Search speed (knots)
Item 21:	ALTTYPE	Search altitude or NVG type as listed below: • Helicopter data files - search altitude in feet; • UTB data files - NVG type used. (1 = AN/PVS-5, 2 = AN/PVS-7)
Item 22:	POS	Position on search unit for detections or -9 for all missed targets. Position codes are shown below.



HELICOPTER



UTB

Item 23:	LO	Lookout identification number for detections or -9 for all missed targets.
Item 24:	EXP	Lookout experience with NVGs (hours) for detections or -9 for all missed targets.
Item 25:	TYNO	Target type (1 = skiff target, 2 = raft target, and 3 = PIW target)
Item 26:	SUBTY	Target subtype as listed below: • Skiff (0 = 18-foot skiff, 1 = 21-foot skiff) • Raft (0 = raft without retroreflective tape, -1= raft with retroreflective tape) • PIW (1 = with orange PFD, retroreflective tape, and red Safety Light, -1 = with orange PFD, retroreflective tape, and green PML)

CG-1488 MARCH 5 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0	0.6	0	15	7	0	2.3	0	-1	65	21.6	22.1	0	1	69	1	1	0.7	90	300	2	36	20	2	0
1	0.1	0.9	0	15	6	0	2.3	0	0	65	21.6	22.1	0	1	67	1	0	0.7	90	300	2	36	20	2	0
1	1.2	1.1	0	15	6	0	2.3	0	1	65	21.6	22.1	-1	1	64	1	-1	0.7	90	300	4	38	25	1	0
1	0.2	1.2	0	15	6	0	2.3	0	0	65	21.6	22.1	0	1	63	1	0	0.7	90	300	1	35	120	1	0
1	0.8	1.2	0	15	6	0.2	2.3	0	1	69	21.6	22	-1	1	63	1	-1	0.7	90	300	7	39	6	1	1
1	1	1.3	0	15	6	0.2	2.3	0	0	69	21.6	22	-1	1	63	1	0	0.7	90	300	1	35	120	1	0
1	0	1.3	0	15	6	0.2	2.3	0	0	69	21.6	22	0	1	62	1	0	0.7	90	300	2	36	20	1	1
1	0.2	1.4	0	15	6	0.2	2.3	0	0	69	21.6	22	1	1	62	1	0	0.7	90	300	1	35	120	1	0
1	0.2	1.4	0	15	6	0.2	2.3	0	-1	69	21.6	22	1	1	61	1	1	0.7	90	300	2	36	20	1	1
0	1.1	0.5	0	15	7	0	2.3	0	1	65	21.6	22	-1	1	69	1	-1	0.7	90	300	-9	-9	-9	2	0
0	0.9	0.8	0	15	6	0	2.3	0	-1	65	21.6	22.1	1	1	67	1	1	0.7	90	300	-9	-9	-9	2	0
0	1.2	0.8	0	15	6	0	2.3	0	1	65	21.6	22.1	-1	1	66	1	-1	0.7	90	300	-9	-9	-9	2	0
0	0.8	1.1	0	15	6	0	2.3	0	1	65	21.6	22.1	-1	1	65	1	-1	0.7	90	300	-9	-9	-9	1	1
0	1	1.1	0	15	6	0	2.3	0	-1	65	21.6	22.1	1	1	64	1	1	0.7	90	300	-9	-9	-9	2	0
0	1	1.4	0	15	6	0.2	2.3	0	-1	69	21.6	22	1	1	62	1	1	0.7	90	300	-9	-9	-9	1	1
0	0.7	1.4	0	15	6	0.2	2.3	0	-1	69	21.6	22	1	1	61	1	1	0.7	90	300	-9	-9	-9	1	0
1	0.9	1.7	0	15	7	0.2	2.6	0	0	69	21.7	21.9	-1	1	56	1	-1	0.7	90	300	2	36	20	1	0
1	0.1	1.8	0	15	7	0.2	2.6	0	1	69	21.7	21.9	-1	1	55	1	-1	0.7	90	300	2	36	20	2	0
1	0.5	2	0	15	8	0.2	2.6	0	0	69	21.6	21.8	0	1	53	1	0	0.7	90	300	3	37	6	1	1
1	0.2	2.1	0	15	8	0.2	2.6	0	1	72	21.6	21.8	-1	1	52	1	-1	0.7	90	300	2	36	20	2	0
1	0.5	2.2	0	15	8	0.2	2.6	0	1	72	21.6	21.8	-1	1	51	1	-1	0.7	90	300	3	37	6	1	1
1	0.1	2.4	0	15	8	0.2	2.6	0	1	72	21.6	21.8	-1	1	48	1	-1	0.7	90	300	1	35	120	1	0
1	0.3	2.7	0	15	8	0.2	2.6	0	0	72	21.6	21.8	-1	1	46	1	0	0.7	90	300	2	36	20	1	1
0	1.6	1.5	0	15	7	0.2	2.6	0	0	69	21.6	21.9	0	1	58	1	0	0.7	90	300	-9	-9	-9	1	0
0	0.8	1.7	0	15	7	0.2	2.6	0	0	69	21.7	21.9	0	1	56	1	0	0.7	90	300	-9	-9	-9	2	0
0	0.4	1.7	0	15	7	0.2	2.6	0	0	69	21.7	21.9	0	1	56	1	0	0.7	90	300	-9	-9	-9	1	0
0	1	1.9	0	15	7	0.2	2.6	0	0	69	21.6	21.8	0	1	54	1	0	0.7	90	300	-9	-9	-9	2	0
0	1.1	1.9	0	15	8	0.2	2.6	0	0	69	21.6	21.8	0	1	53	1	0	0.7	90	300	-9	-9	-9	1	0
0	1.5	1.9	0	15	8	0.2	2.6	0	0	69	21.6	21.8	0	1	53	1	0	0.7	90	300	-9	-9	-9	1	1
0	1.2	2	0	15	8	0.2	2.6	0	0	72	21.6	21.8	0	1	53	1	0	0.7	90	300	-9	-9	-9	2	0
0	1.4	2.2	0	15	8	0.2	2.6	0	0	72	21.6	21.8	0	1	52	1	0	0.7	90	300	-9	-9	-9	1	1
0	1	2.2	0	15	8	0.2	2.6	0	0	72	21.6	21.8	0	1	52	1	0	0.7	90	300	-9	-9	-9	1	0
0	0.7	2.2	0	15	8	0.2	2.6	0	0	72	21.6	21.8	0	1	50	1	0	0.7	90	300	-9	-9	-9	2	0
0	1.7	2.4	0	15	8	0.2	2.6	0	0	72	21.6	21.8	0	1	48	1	0	0.7	90	300	-9	-9	-9	1	1
0	1.5	2.9	0	15	8	0.2	3	0	0	72	21.6	21.8	0	1	43	1	0	0.7	90	300	-9	-9	-9	1	1
1	0.9	3.4	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	19	1	0	0.7	90	300	2	36	20	2	0
1	0	3.5	0	15	7	0.3	3	0	0	61	21.3	21.7	0	1	17	1	0	0.7	90	300	2	36	20	2	0
1	0.8	3.9	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	14	1	0	0.7	90	300	4	38	25	1	1
1	0.4	4	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	12	1	1	0.7	90	300	3	37	0	1	0
1	0.2	4.1	0	15	7	0.3	3	0	-1	61	21.3	21.7	1	1	11	1	0	0.7	90	300	4	38	25	1	1
1	0	4.2	0	15	6	0.3	3	0	-1	61	21.3	21.7	1	1	11	0	0	0.7	90	300	3	37	0	1	0
1	0	4.2	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	10	1	1	0.7	90	300	2	36	20	1	1
0	0.9	3.7	0	15	7	0.3	3	0	-1	61	21.3	21.7	1	1	16	1	0	0.7	90	300	-9	-9	-9	2	0
0	0	3.7	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	15	1	0	0.7	90	300	-9	-9	-9	2	0
0	0.6	3.7	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	15	1	0	0.7	90	300	-9	-9	-9	2	0
0	1.3	3.8	0	15	7	0.3	3	0	-1	61	21.3	21.7	1	1	14	1	0	0.7	90	300	-9	-9	-9	2	0
0	1.7	3.9	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	13	1	0	0.7	90	300	-9	-9	-9	1	1
0	1.1	4	0	15	7	0.3	3	0	-1	61	21.3	21.7	1	1	13	1	0	0.7	90	300	-9	-9	-9	2	0
0	1.1	4	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	13	1	0	0.7	90	300	-9	-9	-9	1	0
0	0.8	4.1	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	12	1	0	0.7	90	300	-9	-9	-9	1	1
0	1	4.1	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	11	1	0	0.7	90	300	-9	-9	-9	1	0
0	1.3	4.2	0	15	6	0.3	3	0	-1	61	21.3	21.7	1	1	10	0	0	0.7	90	300	-9	-9	-9	1	1
0	0.8	4.3	0	15	6	0.3	3	0	-1	68	21.3	21.7	1	1	10	1	0	0.7	90	300	-9	-9	-9	1	0
1	0.3	4.5	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	6	1	1	0.7	90	300	4	38	25	1	0
1	0.1	4.5	0	15	6	0.3	3	0	0	68	21.3	21.7	1	1	6	1	1	0.7	90	300	4	38	25	2	0
1	0.5	4.8	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	4	1	-1	0.7	90	300	3	37	0	1	1
1	0	4.9	0	15	6	0.3	3	0	0	68	21.3	21.7	-1	1	2	1	-1	0.7	90	300	4	38	25	2	0

CG-1488 MARCH 5 1990 (Cont'd)

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.4	5.4	0	15	7	0.3	3	0	-1	68	21.3	21.6	0	1	-3	0	0	0.7	90	300	4	38	25	1	1
0	1	4.5	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	-6	1	0	0.7	90	300	-9	-9	-9	2	0
0	0.7	4.5	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	6	1	0	0.7	90	300	-9	-9	-9	1	0
0	0.8	4.7	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	4	1	0	0.7	90	300	-9	-9	-9	2	0
0	0.5	5	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	3	1	0	0.7	90	300	-9	-9	-9	1	1
0	0.9	5	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	2	1	0	0.7	90	300	-9	-9	-9	1	0
0	0.3	5.2	0	15	7	0.3	3	0	0	68	21.3	21.6	0	1	0	1	0	0.7	90	300	-9	-9	-9	1	0
0	1.3	4.8	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	4	1	0	0.7	90	300	-9	-9	-9	1	0
0	1.4	4.8	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	4	1	0	0.7	90	300	-9	-9	-9	1	1
0	1.2	4.8	0	15	6	0.3	3	0	0	68	21.3	21.7	0	1	3	1	0	0.7	90	300	-9	-9	-9	2	0
0	1.5	5.2	0	15	6	0 3	3	0	0	68	21.3	21.7	0	1	-1	1	0	0.7	90	300	-9	-9	-9	1	1

EOF

CG-1488 **MARCH 9 1990**

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
0	1.5	0.6	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	54	1	0	1	90	300	-9	-9	-9	3	-1
0	0.1	0	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	50	1	0	1	90	300	-9	-9	-9	3	-1
0	0.8	0.1	0	15	10	0.3	5.9	0	0	63	21.3	20.8	-1	1	51	1	0	1	90	300	-9	-9	-9	3	-1
0	1.4	0.1	0	15	10	0.3	5.9	0	0	63	21.3	20.8	0	1	51	1	1	1	90	300	-9	-9	-9	3	-1
0	0.9	0.1	0	15	10	0.3	5.9	0	0	63	21.3	20.8	-1	1	51	1	0	1	90	300	-9	-9	-9	3	-1
0	0.9	0.1	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	51	1	0	1	90	300	-9	-9	-9	3	-1
0	2	0.2	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	1.5	0.2	0	15	10	0.3	5.9	0	0	63	21.3	20.8	-1	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	0.7	0.2	0	15	10	0.3	5.9	0	0	63	21.3	20.8	0	1	52	1	-1	1	90	300	-9	-9	-9	3	-1
0	1	0.3	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	0.2	0.3	0	15	10	0.3	5.9	0	0	63	21.3	20.8	-1	1	[illegible]	1	0	1	90	300	-9	-9	-9	3	-1
0	1.4	0.4	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	1.1	0.4	0	15	10	0.3	5.9	0	0	63	21.3	20.8	-1	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	1.8	0.5	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	1.5	0.5	0	15	10	0.3	5.9	0	0	63	21.3	20.8	-1	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	0.5	0.5	0	15	10	0.3	5.9	0	0	63	21.3	20.8	-1	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	1.4	0.5	0	15	10	0.3	5.9	0	0	63	21.3	20.8	0	1	53	1	-1	1	90	300	-9	-9	-9	3	-1
0	0.4	0.6	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	54	1	0	1	90	300	-9	-9	-9	3	-1
0	1.2	0.6	0	15	10	0.3	5.9	0	0	63	21.3	20.8	1	1	54	1	0	1	90	300	-9	-9	-9	3	-1
0	1.2	0.6	0	15	6	0.2	6.2	0	0	63	21.3	20.8	0	1	55	1	1	1	90	300	-9	-9	-9	3	-1
0	0.4	0.7	0	15	6	0.2	6.2	0	0	63	21.3	20.8	0	1	55	1	1	1	90	300	-9	-9	-9	3	-1
0	1.1	0.7	0	15	6	0.2	6.2	0	0	63	21.3	20.8	0	1	56	1	1	1	90	300	-9	-9	-9	3	-1
0	1.5	0.7	0	15	6	0.2	6.2	0	1	63	21.3	20.8	-1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1	0.8	0	15	6	0.2	6.2	0	0	63	21.3	20.8	0	1	56	1	-1	1	90	300	-9	-9	-9	3	-1
0	1.7	0.8	0	15	6	0.2	6.2	0	0	63	21.3	20.8	0	1	56	1	-1	1	90	300	-9	-9	-9	3	-1
0	0.8	0.8	0	15	6	0.2	6.2	0	0	63	21.3	20.8	0	1	56	1	-1	1	90	300	-9	-9	-9	3	-1
0	0.5	1	0	15	6	0.2	6.2	0	0	63	21.3	20.8	0	1	56	1	1	1	90	300	-9	-9	-9	3	-1
0	1.6	1.1	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	56	1	1	1	90	300	-9	-9	-9	3	-1
0	0.4	1.1	0	15	6	0.2	6.2	0	-1	63	21.3	21	1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	0.6	1.1	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	56	1	-1	1	90	300	-9	-9	-9	3	-1
0	1	1.1	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	56	1	1	1	90	300	-9	-9	-9	3	-1
0	1.2	1.1	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	56	1	-1	1	90	300	-9	-9	-9	3	-1
0	2	1.1	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	56	1	1	1	90	300	-9	-9	-9	3	-1
0	1	1.2	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	56	1	1	1	90	300	-9	-9	-9	3	-1
0	0.4	1.2	0	15	6	0.2	6.2	0	1	63	21.3	21	-1	1	56	1	0	1	90	300	-9	9	-9	3	-1
0	1	1.2	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	56	1	-1	1	90	300	-9	-9	-9	3	-1
0	0	1.2	0	15	6	0.2	6.2	0	0	63	21.3	21	-1	1	57	1	0	1	90	300	-9	-9	-9	3	-1
0	1.2	1.3	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	57	1	-1	1	90	300	-9	-9	-9	3	-1
0	2	1.4	0	15	6	0.2	6.2	0	0	63	21.3	21	0	1	57	1	-1	1	90	300	-9	-9	-9	3	-1
1	0.1	1.4	0	15	6	0.2	5.9	0	0	69	21.4	21.5	1	1	57	0	0	1	90	300	1	35	125	3	-1
1	0.2	1.6	0	15	6	0.2	5.9	0	0	69	21.4	21.5	0	1	56	1	0	1	90	300	1	35	125	3	-1
1	0	1.7	0	15	6	0.2	5.9	0	0	69	21.4	21.5	-1	1	56	1	0	1	90	300	2	36	25	3	-1
0	0.7	1.5	0	15	6	0.2	5.9	0	0	69	21.4	21.5	-1	1	57	1	0	1	90	300	-9	-9	-9	3	-1
0	0.9	1.5	0	15	6	0.2	5.9	0	0	69	21.4	21.5	0	1	57	1	1	1	90	300	-9	-9	-9	3	-1
0	0.8	1.5	0	15	6	0.2	5.9	0	0	69	21.4	21.5	-1	1	57	1	0	1	90	300	-9	-9	-9	3	-1
0	1.2	1.5	0	15	6	0.2	5.9	0	0	69	21.4	21.5	1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1.3	1.6	0	15	6	0.2	5.9	0	0	69	21.4	21.5	-1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1.3	1.7	0	15	6	0.2	5.9	0	0	69	21.4	21.5	1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	0.9	1.8	0	15	6	0.2	5.9	0	0	69	21.4	21.5	-1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1.9	1.9	0	15	6	0.2	5.9	0	0	69	21.5	21.7	1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1.5	1.9	0	15	6	0.2	5.9	0	0	69	21.5	21.7	-1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	0.4	1.9	0	15	6	0.2	5.9	0	0	69	21.5	21.7	-1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1.1	1.9	0	15	6	0.2	5.9	0	0	69	21.5	21.7	0	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1.5	1.9	0	15	6	0.2	5.9	0	0	69	21.5	21.7	1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	0.4	1.9	0	15	6	0.2	5.9	0	0	69	21.5	21.7	1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
0	1.1	2	0	15	6	0.2	5.9	0	0	69	21.5	21.7	1	1	56	1	0	1	90	300	-9	-9	-9	3	-1
1	0.2	2.6	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	52	1	0	1	90	300	1	35	125	3	-1
0	1.3	2.1	0	15	6	0.2	5.9	0	0	69	21.5	21.7	0	1	55	1	0	1	90	300	-9	-9	-9	3	-1
0	0.3	2.1	0	15	6	0.2	5.9	0	0	69	21.5	21.7	0	1	55	1	0	1	90	300	-9	-9	-9	3	-1

CG-1488 MARCH 9 1990 (Cont'd)

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
0	1.2	2.1	0	15	6	0.2	5.9	0	0	69	21.5	21.7	0	1	55	1	0	1	90	300	-9	-9	-9	3	-1
0	1.4	2.1	0	15	6	0.2	5.9	0	0	69	21.5	21.7	-1	1	55	1	0	1	90	300	-9	-9	-9	3	-1
0	1.2	2.2	0	15	6	0.2	5.9	0	0	69	21.5	21.7	0	1	55	1	0	1	90	300	-9	-9	-9	3	-1
0	1.7	2.2	0	15	6	0.2	5.9	0	0	69	21.3	21.8	0	1	54	1	0	1	90	300	-9	-9	-9	3	-1
0	0.8	2.2	0	15	6	0.2	5.9	0	0	69	21.3	21.8	0	1	54	1	0	1	90	300	-9	-9	-9	3	-1
0	0.6	2.4	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	1.6	2.5	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	0.6	2.5	0	15	7	0.3	5.6	0	0	69	21.3	21.8	1	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	1	2.5	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	1.5	2.6	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	53	1	0	1	90	300	-9	-9	-9	3	-1
0	1.7	2.6	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	1	2.6	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	0.3	2.6	0	15	7	0.3	5.6	0	0	69	21.3	21.8	-1	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	1.1	2.7	0	15	7	0.3	5.6	0	0	69	21.3	21.8	0	1	52	1	0	1	90	300	-9	-9	-9	3	-1
0	1.4	2.7	0	15	7	0.3	5.6	0	0	69	21.1	22	0	1	51	1	0	1	90	300	-9	-9	-9	3	-1
0	0.3	2.7	0	15	7	0.3	5.6	0	0	69	21.1	22	0	1	51	1	0	1	90	300	-9	-9	-9	3	-1
0	1.2	2.8	0	15	7	0.3	5.6	0	0	69	21.1	22	0	1	51	1	0	1	90	300	-9	-9	-9	3	-1
0	0.9	2.8	0	15	7	0.3	5.6	0	0	69	21.1	22	-1	1	51	1	-1	1	90	300	-9	-9	-9	3	-1
0	0.7	2.8	0	15	7	0.3	5.6	0	0	69	21.1	22	0	1	50	1	0	1	90	300	-9	-9	-9	3	-1
0	1.6	2.8	0	15	7	0.3	5.6	0	0	69	21.1	22	0	1	50	1	0	1	90	300	-9	-9	-9	3	-1
0	0.7	2.9	0	15	7	0.3	5.6	0	0	69	21.1	22	0	1	50	1	0	1	90	300	-9	-9	-9	3	-1
0	0.5	3.1	0	15	7	0.3	5.6	0	0	69	21.1	22	0	1	48	1	0	1	90	300	-9	-9	-9	3	-1
0	1.5	3.1	0	15	7	0.3	5.6	0	0	69	21.3	22.2	0	1	48	1	0	1	90	300	-9	-9	-9	3	-1
0	0.3	3.1	0	15	7	0.3	5.6	0	0	69	21.3	22.2	1	1	48	1	1	1	90	300	-9	-9	-9	3	-1
0	0.9	3.1	0	15	7	0.3	5.6	0	0	69	21.3	22.2	0	1	48	1	0	1	90	300	-9	-9	-9	3	-1
0	1.2	3.2	0	15	5	0.4	5.2	0	0	69	21.3	22.2	0	1	48	0	0	1	90	300	-9	-9	-9	3	-1
0	2	3.2	0	15	5	0.4	5.2	0	0	69	21.3	22.2	0	1	48	0	0	1	90	300	-9	-9	-9	3	-1
0	0.9	3.2	0	15	5	0.4	5.2	0	0	69	21.3	22.2	0	1	48	0	0	1	90	300	-9	-9	-9	3	-1
0	0.3	3.2	0	15	5	0.4	5.2	0	0	69	21.3	22.2	-1	1	48	0	-1	1	90	300	-9	-9	-9	3	-1
0	0	3.3	0	15	5	0.4	5.2	0	0	69	21.3	22.2	0	1	47	0	0	1	90	300	-9	-9	-9	3	-1
0	1	3.3	0	15	5	0.4	5.2	0	0	69	21.3	22.2	0	1	47	0	0	1	90	300	-9	-9	-9	3	-1

EOF

CG-1488 MARCH 12 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0	0.6	0	15	16	0.1	3.3	0	0	71	23	22.1	0	1	5	1	0	1	90	300	4	38	30	2	0
1	0.3	0.8	0	15	16	0.1	3.3	0	0	71	23	21.9	0	1	6	0	0	1	90	300	7	39	16	2	-1
1	0.3	0.9	0	15	16	0.1	3	0	0	71	23	21.9	0	1	8	1	0	1	90	300	7	39	16	2	-1
1	0.6	1	0	15	16	0.1	3	0	0	71	23	21.9	0	1	8	1	0	1	90	300	7	39	16	2	-1
0	0.4	0.2	0	15	16	0.1	3.3	0	0	71	23	22.1	0	1	0	0	0	1	90	300	-9	-9	-9	2	-1
0	0.3	0.2	0	15	16	0.1	3.3	0	0	71	23	22.1	0	1	1	0	0	1	90	300	-9	-9	-9	2	-1
0	0.8	0.2	0	15	16	0.1	3.3	0	0	71	23	22.1	0	1	1	0	0	1	90	300	-9	-9	-9	2	-1
0	0.6	0.3	0	15	16	0.1	3.3	0	0	71	23	22.1	0	1	2	0	0	1	90	300	-9	-9	-9	2	-1
0	0.9	0.8	0	15	16	0.1	3	0	0	71	23	21.9	0	1	6	0	0	1	90	300	-9	-9	-9	2	0
0	0.6	0.9	0	15	16	0.1	3	0	0	71	23	21.9	0	1	6	0	0	1	90	300	-9	-9	-9	2	-1
0	0.7	1	0	15	16	0.1	3	0	0	71	23	21.9	0	1	8	1	0	1	90	300	-9	-9	-9	2	0
0	0.6	1.1	0	15	16	0.1	3	0	0	71	23	21.9	0	1	10	1	0	1	90	300	-9	-9	-9	2	0
1	0.3	1.8	0	15	16	0.1	3	0	1	71	23	22	-1	1	17	1	0	1	90	300	3	39	16	2	0
1	0.8	1.9	0	15	12	0.1	3	0	-1	71	23	22	1	1	19	1	0	1	90	300	3	39	16	2	0
1	0.3	2.2	0	15	12	0.1	3	0	0	71	23	21.9	0	1	21	1	0	1	90	300	2	35	130	2	-1
1	0.5	2.2	0	15	12	0.1	3	0	-1	71	23	21.9	1	1	22	1	0	1	90	300	2	35	130	2	-1
0	0.9	1.9	0	15	12	0.1	3	0	1	71	23	22	-1	1	19	1	0	1	90	300	-9	-9	-9	2	-1
0	0.4	2.1	0	15	12	0.1	3	0	1	71	23	21.9	-1	1	20	1	0	1	90	300	-9	-9	-9	2	0
0	0.9	2.1	0	15	12	0.1	3	0	-1	71	23	21.9	1	1	21	1	0	1	90	300	-9	-9	-9	2	-1
0	0.6	2.3	0	15	12	0.1	3	0	-1	71	23	21.9	1	1	22	1	0	1	90	300	-9	9	-9	2	0
0	0.1	2	0	15	12	0.1	3	0	1	71	23	21.9	-1	1	20	1	0	1	90	300	-9	-9	-9	2	-1
0	1.2	0.5	0	15	16	0.1	3.3	0	0	71	23	22.1	0	1	4	1	0	1	90	300	-9	-9	-9	2	0
EOF																									

CG-1488 MARCH 14 1990

DET	LATRNG	TOT	PRECIP	VIS	WSP	CLDC	HS	WCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.2	0	0	15	14	0.1	3.3	1	0	74	26	24	0	1	-15		0	0.7	90	300	2	36	35	3	1
1	0.5	0.1	0	15	15	0.3	3.3	1	0	78	26	24	1	1	-14	0	0	0.7	90	300	7	39	23	3	1
1	0.6	0.1	0	15	15	0.3	3.3	1	1	78	26	24	-1	1	-14	0	1	0.7	90	300	1	35	135	3	1
1	0.2	0.2	0	15	15	0.3	3.3	1	0	78	26	24	0	1	-13	0	0	0.7	90	300	7	39	23	3	1
1	0.6	0.3	0	15	15	0.3	3.3	1	0	78	26	24	1	1	-13	0	0	0.7	90	300	1	35	135	3	1
1	0.5	0.4	0	15	15	0.3	3.3	1	0	78	26	24	1	1	-12	0	0	0.7	90	300	4	41	14	3	1
1	0.4	0.5	0	15	15	0.3	3.3	1	1	78	26	24	-1	1	-11	0	1	0.7	90	300	1	35	135	3	1
0	1.2	0.1	0	15	15	0.3	3.3	1	0	78	26	24	-1	1	-15	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.8	0.1	0	15	15	0.3	3.3	1	0	78	26	24	0	1	-15	0	0	0.7	90	300	-9	-9	9	3	1
0	1.5	0.1	0	15	15	0.3	3.3	1	0	78	26	24	1	1	-14	0	0	0.7	90	300	-9	-9		3	1
0	1.3	0.2	0	15	15	0.3	3.3	1	0	78	26	24	-1	1	-14	0	0	0.7	90	300	-9	-9	[illegible]	3	1
0	1.2	0.2	0	15	15	0.3	3.3	1	0	78	26	24	1	1	-14	0	0	0.7	[illegible]	300	-9	-9	-9	3	1
0	0.9	0.2	0	15	15	0.3	3.3	1	0	78	26	24	-1	1	-14	0	0	0.7	90	300	-9	9	-9	3	1
0	0.7	0.3	0	15	15	0.3	3.3	1	0	78	26	24	-1	1	-13	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.6	0.3	0	15	15	0.3	3.3	1	0	78	26	24	1	1	-12	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.7	0.3	0	15	15	0.3	3.3	1	0	78	26	24	-1	1	-12	0	0	0.7	90	300	-9	-9	-9	3	1
0	1	0.4	0	15	15	0.3	3.3	1	0	78	26	24	0	1	-12	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.6	0.4	0	15	15	0.3	3.3	1	0	78	26	24	-1	1	-11	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.2	0.4	0	15	15	0.3	3.3	1	0	78	26	24	1	1	-11	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.5	0.5	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-11	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.7	0.5	0	15	15	0.3	3.3	1	0	78	26	23.9	1	1	-10	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.4	0.6	0	15	15	0.3	3.3	1	0	78	26	23.9	1	1	-10	0	0	0.7	90	300	-9	-9	-9	3	1
1	0.3	0.6	0	15	15	0.3	3.3	1	0	78	26	23.9	1	1	-9	0	0	0.7	90	300	1	35	135	3	1
1	0.4	0.8	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-6	0	0	0.7	90	300	4	40	6	3	1
1	0.3	0.9	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	-6	0	0	0.7	90	300	1	35	135	3	1
1	0	1	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	-4	0	0	0.7	90	300	1	35	135	3	1
1	0.3	1.1	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-4	0	0	0.7	90	300	3	39	23	3	1
1	0.5	1.1	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-3	0	0	0.7	90	300	4	40	6	3	1
1	0.2	1.2	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-2	0	0	0.7	90	300	1	35	135	3	1
0	1.4	0.7	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-8	0	0	0.7	90	300	-9	-9	-9	3	1
0	2	0.7	0	15	15	0.3	3.3	1	0	78	26	23.9	-1	1	-7	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.6	0.7	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-7	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.9	0.7	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-7	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.8	0.8	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-6	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.6	0.8	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-6	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.1	0.9	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-6	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.8	0.9	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	-5	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.5	0.9	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-5	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.5	1	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-5	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.8	1.1	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-3	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.9	1.1	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-3	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.7	1.1	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	-3	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.1	1.2	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-3	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.6	1.3	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-2	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.4	0.7	0	15	15	0.3	3.3	1	0	78	26	23.9	1	1	-6	0	0	0.7	90	300	-9	-9	-9	3	1
1	0.5	1.4	0	15	15	0.3	3.3	1	1	78	26	23.8	-1	1	1	0	0	0.7	90	300	1	35	135	3	1
1	0	1.5	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	2	0	0	0.7	90	300	2	36	35	3	1
1	0.2	1.7	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	4	0	0	0.7	90	300	1	35	135	3	1
0	0.8	1.3	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	-1	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.4	1.3	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	0	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.4	1.3	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	0	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.7	1.4	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	0	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.4	1.4	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	1	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.6	1.4	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	1	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.5	1.5	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	2	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.1	1.5	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	2	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.6	1.5	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	2	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.8	1.6	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	3	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.6	1.7	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	3	0	0	0.7	90	300	-9	-9	-9	3	1

CG-1488 MARCH 14 1990 (Cont'd)

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
0	1.6	1.7	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	3	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.7	1.8	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	4	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.3	1.8	0	15	15	0.3	3.3	1	0	78	26	23.8	1	1	4	0	0	0.7	90	300	-9	-9	-9	3	1
0	0.5	1.8	0	15	15	0.3	3.3	1	0	78	26	23.8	-1	1	4	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.8	1.8	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	5	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.4	1.9	0	15	15	0.3	3.6	1	0	76	24	23.8	1	1	5	0	0	0.7	90	300	-9	-9	-9	3	1
0	1.5	1.9	0	15	15	0.3	3.6	1	0	76	24	23.8	1	1	6	0	0	0.7	90	300	-9	-9	-9	3	1
1	0.3	2	0	15	15	0.3	3.6	1	0	76	24	23.8	1	1	8	1	0	0.7	90	300	1	35	135	3	1
1	0	2.3	0	15	15	0.3	3.6	1	0	76	24	23.8	-1	1	11	1	0	0.7	90	300	2	36	35	3	1
1	0.2	2.6	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	13	1	-1	0.7	90	300	1	35	135	3	1
0	1.5	2	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	8	1	1	0.7	90	300	-9	-9	-9	3	1
0	2	2	0	15	15	0.3	3.6	1	0	76	24	23.8	-1	1	8	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.6	2.1	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	9	1	-1	0.7	90	300	-9	-9	-9	3	1
0	0.7	2.1	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	9	1	1	0.7	90	300	-9	-9	-9	3	1
0	1.7	2.1	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	9	1	-1	0.7	90	300	-9	-9	-9	3	1
0	1.7	2.1	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	9	1	1	0.7	90	300	-9	-9	-9	3	1
0	1.2	2.2	0	15	15	0.3	3.6	1	0	76	24	23.8	1	1	9	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.4	2.2	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	10	1	-1	0.7	90	300	-9	-9	-9	3	1
0	2	2.2	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	10	1	1	0.7	90	300	-9	-9	-9	3	1
0	1.1	2.2	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	10	1	-1	0.7	90	300	-9	-9	-9	3	1
0	0.3	2.2	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	10	1	1	0.7	90	300	-9	-9	-9	3	1
0	1.5	2.3	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	11	1	-1	0.7	90	300	-9	-9	-9	3	1
0	1.5	2.3	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	11	1	1	0.7	90	300	-9	-9	-9	3	1
0	0.4	2.4	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	12	1	1	0.7	90	300	-9	-9	-9	3	1
0	2	2.4	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	12	1	-1	0.7	90	300	-9	-9	-9	3	1
0	0.4	2.5	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	12	1	-1	0.7	90	300	-9	-9	-9	3	1
0	1.8	2.5	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	13	1	1	0.7	90	300	-9	-9	-9	3	1
0	0.9	2.5	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	13	1	1	0.7	90	300	-9	-9	-9	3	1
0	1	2.5	0	15	15	0.3	3.6	1	0	76	24	23.8	-1	1	13	1	0	0.7	90	300	-9	-9	-9	3	1
0	1	2.5	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	13	1	-1	0.7	90	300	-9	-9	-9	3	1
0	1.6	2.6	0	15	15	0.3	3.6	1	0	76	24	23.8	0	1	14	1	-1	0.7	90	300	-9	-9	-9	3	1
0	0.4	2.7	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	14	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.3	2.7	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	15	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.9	2.7	0	15	15	0.3	4.3	1	0	68	25	23.8	0	1	15	1	1	0.7	90	300	-9	-9	-9	3	1
0	0.4	2.7	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	15	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.5	2.8	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	15	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.5	2.8	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	16	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.5	2.8	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	16	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.1	2.8	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	16	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.2	2.9	0	15	15	0.3	4.3	1	0	68	25	23.8	0	1	16	1	-1	0.7	90	300	-9	-9	-9	3	1
0	0.6	2.9	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	17	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.7	2.9	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	17	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.7	2.9	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	17	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.6	3	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	17	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.9	3	0	15	15	0.3	4.3	1	0	68	25	23.8	0	1	18	1	1	0.7	90	300	-9	-9	-9	3	1
0	0.2	3	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	18	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.8	3	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	18	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.1	3.1	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	18	1	0	0.7	90	300	-9	-9	-9	3	1
0	0.4	3.1	0	15	15	0.3	4.3	1	0	68	25	23.8	-1	1	18	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.6	3.1	0	15	15	0.3	4.3	1	0	68	25	23.8	0	1	18	1	-1	0.7	90	300	-9	-9	-9	3	1
0	1.6	3.2	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	18	1	0	0.7	90	300	-9	-9	-9	3	1
0	1.4	3.2	0	15	15	0.3	4.3	1	0	68	25	23.8	1	1	19	1	0	0.7	90	300	-9	-9	-9	3	1

EOF

CG-1488 MARCH 19 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPI	POS	LO	EXP	TYNO	SUBTY
1	0.8	0	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-67	0	1	0.2	90	300	3	44	2	3	1
1	0.5	0.1	0	15	8	0.9	2.3	0	1	78	23.3	23.5	-1	1	-66	0	1	0.2	90	300	2	43	4	3	1
1	0.1	0.2	0	15	8	0.9	2.3	0	0	78	23.3	23.5	0	1	-66	0	0	0.2	90	300	1	42	4	3	1
1	1	0.2	0	15	8	0.9	2.3	0	1	78	23.3	23.5	-1	1	-65	0	0	0.2	90	300	2	43	4	3	1
1	0.1	0.3	0	15	8	0.9	2.3	0	0	[illegible]	23.3	23.5	0	1	-65	0	0	0.2	90	300	2	43	4	3	1
1	0.3	0.3	0	15	8	0.9	2.3	0	-1	78	23.3	23.5	0	1	-64	0	0	0.2	90	300	2	43	4	3	1
1	0.5	0.5	0	15	8	0.9	2.3	0	1	78	23.3	23.5	0	1	-63	0	0	0.2	90	300	2	43	4	3	1
1	0.4	0.6	0	15	8	0.9	2.3	0	-1	78	23.3	23.5	0	1	-62	0	0	0.2	90	300	2	43	4	3	1
1	1.1	0.7	0	15	8	0.9	2.3	0	1	78	23.3	23.5	-1	1	-60	0	1	0.2	90	300	2	43	4	3	1
1	1	0.8	0	15	8	0.9	2.3	0	1	78	23.3	23.5	-1	1	-59	0	1	0.2	90	300	3	44	2	3	1
1	0.2	0.8	0	15	8	0.9	2.3	0	0	78	23.3	23.5	0	1	-59	0	0	0.2	90	300	1	42	4	3	1
1	0.2	0.9	0	15	8	0.9	2.3	0	0	78	23.3	23.5	0	1	-59	0	0	0.2	90	300	7	46	25	3	1
1	0.1	1	0	15	8	0.9	2.3	0	-1	78	23.3	23.5	1	1	-57	0	-1	0.2	90	300	3	44	2	3	1
1	0.6	1.1	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-57	0	1	0.2	90	300	3	44	2	3	1
1	0.4	1.1	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-56	0	1	0.2	90	300	3	44	2	3	1
1	0.6	1.2	0	15	7	0.9	2.3	0	0	78	23.3	23.5	1	1	-55	0	-1	0.2	90	300	3	44	2	3	1
0	1.4	0	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-67	0	1	0.2	90	300	-9	-9	-9	3	1
0	0.8	0.3	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-64	0	-1	0.2	90	300	-9	-9	-9	3	1
0	0.5	0.4	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-64	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1.5	0.4	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-64	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1.3	0.5	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-63	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1	0.5	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-63	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1.3	0.7	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-61	0	1	0.2	90	300	-9	-9	-9	3	1
0	1.5	0.7	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-60	0	-1	0.2	90	300	-9	-9	-9	3	1
0	0.7	0.9	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-58	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1.3	0.9	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-58	0	1	0.2	90	300	-9	-9	-9	3	1
0	0.9	1	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-58	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1	1.1	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-57	0	-1	0.2	90	300	-9	-9	-9	3	1
0	0.4	1.3	0	15	7	0.9	2.3	0	0	78	23.3	23.5	1	1	-55	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1.5	1	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-58	0	1	0.2	90	300	-9	-9	-9	3	1
1	0.3	1.6	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-51	0	0	0.2	90	300	3	44	2	3	1
1	1.1	1.7	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-50	0	0	0.2	90	300	2	43	4	3	1
1	0.2	1.7	0	15	7	0.9	2	0	1	78	23.3	23.5	-1	1	-50	0	1	0.2	90	300	1	42	4	3	1
1	0.8	1.8	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-48	0	0	0.2	90	300	3	44	2	3	1
1	0.7	1.8	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-48	0	0	0.2	90	300	2	43	4	3	1
1	0.5	1.8	0	15	7	0.9	2	0	0	78	23.3	23.5	1	1	-48	0	0	0.2	90	300	3	44	2	3	1
1	0.6	1.9	0	15	7	0.9	2	0	0	78	23.3	23.5	-1	1	-46	0	0	0.2	90	300	3	44	2	3	1
1	0.2	2	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-46	0	0	0.2	90	300	1	42	4	3	1
1	0.4	2	0	15	5	0.3	2	0	0	78	23.3	23.5	0	1	-46	0	0	0.2	90	300	1	42	4	3	1
1	0	2.1	0	15	5	0.3	2	0	1	78	23.3	23.5	-1	1	-45	0	1	0.2	90	300	7	45	4	3	1
1	0.1	2.1	0	15	5	0.3	2	0	1	78	23.3	23.5	-1	1	-44	0	1	0.2	90	300	1	42	4	3	1
0	1.3	1.5	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-51	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.2	1.6	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-50	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.7	1.7	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-49	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.6	1.8	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-49	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.8	1.9	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-47	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	2	0	15	5	0.3	2	0	0	78	23.3	23.5	0	1	-46	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.9	2.1	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-46	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.4	2.1	0	15	7	0.9	2	0	0	78	23.3	23.5	0	1	-46	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	2.1	0	15	5	0.3	2	0	0	78	23.3	23.5	0	1	-44	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.2	2.2	0	15	5	0.3	2.3	0	0	78	23.3	23.5	0	1	-43	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.2	2.3	0	15	5	0.3	2.3	0	0	78	23.3	23.5	0	1	-42	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	2.4	0	15	5	0.3	2.3	0	0	78	23.3	23.5	0	1	-42	0	0	0.2	90	300	-9	-9	-9	3	1
1	0.1	3.5	0	15	6	0.9	2.3	0	0	74	24.4	23.5	-1	1	-9	0	1	0.2	90	300	7	44	2	3	1
1	0	3.5	2	15	6	0.9	2.3	0	0	74	24.4	23.5	0	1	-8	0	0	0.2	90	300	1	42	4	3	1
1	0	3.6	2	15	6	0.9	2.3	0	0	74	24.4	23.5	0	1	-7	0	0	0.2	90	300	1	42	4	3	1
1	0.3	3.7	2	15	6	0.9	2.3	0	0	74	24.4	23.5	0	1	-7	0	0	0.2	90	300	2	43	4	3	1
1	0.5	3.9	1	15	6	0.9	2.3	0	-1	74	24.4	23.5	1	1	-5	0	0	0.2	90	300	2	43	4	3	1

CG-1488 MARCH 19 1990 (Cont'd)

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.1	4.2	3	15	6	0.9	2.3	0	0	86	22.8	23.5	0	1	-2	0	1	0.2	90	300	1	42	4	3	1
1	0.2	4.2	3	15	6	0.9	2.3	0	0	86	22.8	23.5	0	1	-1	0	0	0.2	90	300	7	44	2	3	1
0	1.2	3.4	3	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-10	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.3	3.4	0	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-9	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.7	3.5	0	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-8	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.9	3.5	2	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-8	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.9	3.6	2	15	6	0.9	2.3	0	-1	74	24.4	23.5	1	1	-7	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.6	3.7	2	15	6	0.9	2.3	0	-1	74	24.4	23.5	1	1	-7	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.4	3.8	0	15	6	0.9	2.3	0	-1	74	24.4	23.5	1	1	-6	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.4	3.8	0	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-6	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	3.8	0	15	6	0.9	2.3	0	-1	74	24.4	23.5	1	1	-6	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	4	3	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-4	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	4	3	15	6	0.9	2.3	0	1	86	22.8	23.5	-1	1	-3	0	0	0.2	90	300	-9	-9	-9	3	1
0	1	4.1	3	15	6	0.9	2.3	0	1	86	22.8	23.5	-1	1	-2	0	0	0.2	90	300	-9	-9	-9	3	1

EOF

CG-1488 MARCH 22 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.3	0.4	0	15	12	0.4	4.3	0	0	65	22.7	22.4	0	1	-64	0	0	0.2	90	300	7	48	4	2	-1
1	0.2	0.7	0	15	12	0.4	4.3	0	0	65	22.7	22.4	-1	1	-65	0	0	0.2	90	300	1	43	10	2	-1
1	0.1	0.7	0	15	12	0.4	4.3	0	0	65	22.7	22.4	0	1	-65	0	1	0.2	90	300	1	43	10	2	-1
1	0.3	0.8	0	15	12	0.4	4.3	0	-1	65	22.7	22.4	1	1	-65	0	0	0.2	90	300	3	47	0	2	-1
0	0.7	0.3	0	15	12	0.4	4.3	0	1	65	22.7	22.5	-1	1	-64	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.8	0.6	0	15	12	0.4	4.3	0	1	65	22.7	22.4	-1	1	-64	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.8	0.6	0	15	12	0.4	4.3	0	1	65	22.7	22.4	-1	1	-65	0	0	0.2	90	300	-9	-9	-9	2	-1
1	0	1.1	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-66	0	-1	0.2	90	300	1	43	10	2	-1
1	0.4	1.1	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-66	0	-1	0.2	90	300	1	43	10	2	-1
0	0.7	0.7	0	15	12	0.4	4.3	0	1	65	22.7	22.4	-1	1	-65	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.9	1	0	15	12	0.4	4.3	0	1	65	22.7	22.5	-1	1	-66	0	0	0.2	90	300	-9	-9	-9	2	-1
1	0.3	1.6	0	15	12	0.4	4.3	0	0	65	22.7	22.2	0	1	-65	0	0	0.2	90	300	4	46	29	2	-1
1	0.3	1.8	0	15	12	0.4	4.3	0	0	65	22.7	22.2	0	1	-64	0	-1	0.2	90	300	3	47	0	2	-1
1	0.6	2	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-64	0	1	0.2	90	300	1	43	10	2	-1
1	0.3	2.1	0	15	12	0.4	4.3	0	0	65	22.7	22.1	-1	1	-63	0	1	0.2	90	300	1	43	10	2	-1
1	0.4	2.4	0	15	12	0.4	4.3	0	1	65	22.7	22.1	-1	1	-62	0	0	0.2	90	300	2	42	10	2	-1
1	0.7	2.5	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-61	0	1	0.2	90	300	4	46	29	2	-1
1	0.1	2.6	0	15	12	0.4	4.3	0	1	65	22.7	22.1	-1	1	-60	0	0	0.2	90	300	1	43	10	2	-1
0	0.8	1.5	0	15	12	0.4	4.3	0	0	65	22.7	22.2	0	1	-65	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.1	2	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-64	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.8	2.1	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-64	0	0	0.2	90	300	-9	-9	-9	2	-1
0	1	2.3	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-64	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.8	2.5	0	15	12	0.4	4.3	0	0	65	22.7	22.1	0	1	-61	0	0	0.2	90	300	-9	-9	-9	2	-1
1	0.3	3.1	0	15	12	0.4	4.3	0	-1	65	22.7	21.9	1	1	-54	0	-1	0.2	90	300	1	43	10	2	-1
1	0.6	3.3	0	15	14	0.1	3.9	0	1	61	22.2	21.9	-1	1	-52	0	1	0.2	90	300	3	47	0	2	-1
1	0.2	3.3	0	15	14	0.1	3.9	0	0	61	22.2	21.9	0	1	-51	0	0	0.2	90	300	1	43	10	2	-1
0	0.6	3	0	15	12	0.4	4.3	0	1	65	22.7	22	-1	1	-54	0	1	0.2	90	300	-9	-9	-9	2	-1
0	0.8	3.2	0	15	14	0.1	3.9	0	1	61	22.2	21.9	-1	1	-52	0	1	0.2	90	300	-9	-9	-9	2	-1
0	0.9	3.3	0	15	14	0.1	3.9	0	1	61	22.2	21.9	-1	1	-52	0	1	0.2	90	300	-9	-9	-9	2	-1
0	0.5	3.4	0	15	14	0.1	3.9	0	-1	61	22.2	21.9	1	1	-50	0	-1	0.2	90	300	-9	-9	-9	2	-1
1	0.3	3.9	0	15	8	0.3	3.9	0	0	60	21.7	21.8	0	1	-30	0	0	0.2	90	300	4	46	29	2	-1
1	0.2	4.1	0	15	8	0.3	3.9	0	-1	60	21.7	21.9	1	1	-27	0	0	0.2	90	300	2	42	10	2	-1
1	0.2	4.3	0	15	8	0.3	3.9	0	0	60	21.7	21.9	0	1	-24	0	0	0.2	90	300	4	46	29	2	-1
1	0.5	4.4	0	15	8	0.3	3.9	0	0	60	21.7	21.9	0	1	-23	0	0	0.2	90	300	3	47	0	2	-1
1	0.7	4.7	0	15	10	0	3.3	0	0	60	21.7	21.9	0	1	-20	0	0	0.2	90	300	4	46	29	2	-1
1	0.5	4.7	0	15	10	0	3.3	0	0	60	21.7	21.9	0	1	-20	0	-1	0.2	90	300	4	46	29	2	-1
1	0.2	4.9	0	15	10	0	3.3	0	1	60	21.7	21.9	-1	1	-18	0	1	0.2	90	300	2	42	10	2	-1
0	0.8	3.8	0	15	8	0.3	3.9	0	0	60	21.7	21.8	0	1	-30	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.8	4.3	0	15	8	0.3	3.9	0	0	60	21.7	21.9	0	1	-26	0	0	0.2	90	300	-9	-9	-9	2	-1
0	1	4.3	0	15	8	0.3	3.9	0	0	60	21.7	21.9	0	1	-26	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.7	4.4	0	15	8	0.3	3.9	0	0	60	21.7	21.9	0	1	-24	0	0	0.2	90	300	-9	-9	-9	2	-1
0	0.9	4.5	0	15	8	0.3	3.9	0	0	60	21.7	21.9	0	1	-22	0	0	0.2	90	300	-9	-9	-9	2	-1

EOF

CG-1488 **MARCH 23 1990**

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.4	0.2	0	15	12	0.3	3.9	0	0	61	22.2	22.2	-1	1	-56	0	0	0.2	90	300	2	43	16	3	1
1	0.5	0.3	0	15	12	0.3	3.9	0	0	61	22.2	22.2	1	1	-57	0	0	0.2	90	300	4	45	9	3	1
1	0.1	0.3	0	15	12	0.3	3.9	0	0	61	22.2	22.2	0	1	-58	0	1	0.2	90	300	2	43	16	3	1
1	0.2	0.7	0	15	12	0.3	3.9	0	0	61	22.2	22.2	1	1	-59	0	-1	0.2	90	300	1	42	16	3	1
1	0.3	0.8	0	15	12	0.3	3.9	0	0	61	22.2	22.2	0	1	-59	0	1	0.2	90	300	2	43	16	3	1
1	0.7	0.9	0	15	12	0.3	3.9	0	1	61	22.2	22.2	-1	1	-60	0	0	0.2	90	300	4	45	9	3	1
1	0.7	1	0	15	12	0.3	3.9	0	1	61	22.2	22.2	-1	1	-60	0	0	0.2	90	300	4	45	9	3	1
1	0.4	1.1	0	15	12	0.3	3.9	0	0	61	22.2	22.2	0	1	-60	0	0	0.2	90	300	2	43	16	3	1
1	0.2	1.1	0	15	12	0.3	3.9	0	0	61	22.2	22.2	0	1	-60	0	0	0.2	90	300	2	43	16	3	1
1	0.2	1.3	0	15	12	0.3	3.9	0	0	61	22.2	22.2	0	1	-60	0	0	0.2	90	300	2	43	16	3	1
0	0.6	0.1	0	15	12	0.3	3.9	0	1	61	22.2	22.2	-1	1	-56	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.4	0.2	0	15	12	0.3	3.9	0	-1	61	22.2	22.2	1	1	-56	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.2	0.4	0	15	12	0.3	3.9	0	-1	61	22.2	22.2	1	1	-58	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.9	0.6	0	15	12	0.2	3.9	0	1	61	22.2	22.2	-1	1	-58	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	0.9	0	15	12	0.2	3.9	0	-1	61	22.2	22.2	1	1	-59	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.5	1	0	15	12	0.2	3.6	0	-1	61	22.2	22.2	1	1	-60	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.2	1.3	0	15	12	0.2	3.6	0	-1	61	22.2	22.2	1	1	-60	0	0	0.2	90	300	-9	-9	-9	3	1
1	0.2	1.5	0	15	12	0.2	3.6	0	0	61	22.2	22	-1	1	-60	0	0	0.2	90	300	2	43	16	3	1
1	0.2	1.5	0	15	12	0.2	3.6	0	0	61	22.2	22	0	1	-60	0	1	0.2	90	300	2	43	16	3	1
1	0.8	1.6	0	15	12	0.2	3.6	0	0	61	22.2	22	0	1	-60	0	0	0.2	90	300	2	43	16	3	1
1	0.1	1.7	0	15	12	0.2	3.6	0	1	61	22.2	22	-1	1	-60	0	0	0.2	90	300	1	42	16	3	1
1	0.5	1.9	0	15	12	0.2	3.3	0	0	61	22.2	22	-1	1	-59	0	0	0.2	90	300	4	45	9	3	1
1	0.2	2	0	15	12	0.2	3.3	0	1	61	22.2	22	-1	1	-59	0	-1	0.2	90	300	1	42	16	3	1
1	0.3	2.2	0	15	12	0.2	3.3	0	0	61	22.2	22	-1	1	-58	0	0	0.2	90	300	2	43	16	3	1
1	0.1	2.3	0	15	12	0.2	3.3	0	-1	61	22.2	22	1	1	-57	0	0	0.2	90	300	2	43	16	3	1
1	0.7	2.4	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-57	0	0	0.2	90	300	4	45	9	3	1
1	0.2	2.5	0	15	12	0.2	3.3	0	-1	61	22.2	22	0	1	-57	0	1	0.2	90	300	1	42	16	3	1
1	0.3	2.5	0	15	12	0.2	3.3	0	0	61	22.2	22	1	1	-56	0	1	0.2	90	300	1	42	16	3	1
1	0.7	2.6	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-56	0	-1	0.2	90	300	1	42	16	3	1
1	0.6	2.3	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-58	0	0	0.2	90	300	4	45	9	3	1
0	1.2	1.3	0	15	12	0.2	3.6	0	0	61	22.2	22	0	1	-60	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.9	1.6	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-60	0	0	0.2	90	300	-9	-9	-9	3	1
0	1	1.8	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-60	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.7	1.8	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-60	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	1.8	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-59	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.4	2.1	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-58	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.1	2.1	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-58	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.2	2.1	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-58	0	0	0.2	90	300	-9	-9	-9	3	1
0	0.9	2.4	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-57	0	0	0.2	90	300	-9	-9	-9	3	1
0	1.2	2.4	0	15	12	0.2	3.3	0	0	61	22.2	22	0	1	-57	0	0	0.2	90	300	-9	-9	-9	3	1
1	0.5	2.7	0	15	12	0.2	3.6	0	0	61	22.2	22	-1	1	-54	0	0	0.2	90	300	1	42	16	3	1
1	0.4	2.8	0	15	12	0.2	3.6	0	0	61	22.2	22	0	1	-53	0	1	0.2	90	300	1	42	16	3	1
1	0.5	2.9	0	15	12	0.2	3.6	0	1	61	22.2	22	-1	1	-52	0	1	0.2	90	300	4	45	9	3	1
1	0.1	3	0	15	12	0.2	3.6	0	0	61	22.2	22	0	1	-51	0	0	0.2	90	300	2	43	16	3	1
0	0.8	2.9	0	15	12	0.2	3.6	0	1	61	22.2	22	-1	1	-53	0	1	0.2	90	300	-9	-9	-9	3	1
0	0.4	2.9	0	15	12	0.2	3.6	0	-1	61	22.2	22	1	1	-53	0	-1	0.2	90	300	-9	-9	-9	3	1
0	0.5	3	0	15	12	0.2	3.6	0	-1	61	22.2	22	1	1	-52	0	-1	0.2	90	300	-9	-9	-9	3	1
0	0.5	3.1	0	15	12	0.2	3.6	0	-1	61	22.2	22	1	1	-51	0	-1	0.2	90	300	-9	-9	-9	3	1
0	1.2	3.1	0	15	12	0.2	3.6	0	-1	61	22.2	22	1	1	-51	0	-1	0.2	90	300	-9	-9	-9	3	1

EOF

CG-41341 MARCH 5 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.2	2.2	0	15	7	0.2	2.6	0	1	72	21.6	21.8	-1	1	52	1	-1	0.7	15	0	3	22	50	2	0
1	0.1	3.6	0	15	8	0.2	3	0	0	68	21.5	21.7	0	1	35	1	0	0.7	15	0	7	92	3	2	0
0	0.8	3.1	0	15	8	0.2	3	0	-1	68	21.5	21.7	1	1	40	1	1	0.7	15	0	-9	-9	-9	2	0
0	0.9	4.4	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	25	1	-1	0.7	15	0	-9	-9	-9	1	1
0	0.9	5.1	0	15	7	0.3	3	0	-1	61	21.3	21.7	1	1	19	1	1	0.7	15	0	-9	-9	-9	2	0
1	0.1	6.2	0	15	7	0.3	3	0	1	61	21.3	21.7	-1	1	16	1	-1	0.7	15	0	7	92	3	2	0

EOF

CG-41341 MARCH 12 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.3	2.3	0	15	12	0.1	3.5	2	0	71	23	21.6	0	1	26	1	-1	1	12	0	3	13	11	2	0
1	0.3	3.9	0	15	12	0.3	4	2	0	71	23	21.4	0	1	36	1	-1	1	14	0	3	94	1	2	-1
1	0.1	4.9	0	15	16	0.3	4	2	-1	68	23.8	21.4	1	1	40	1	0	1	14	0	4	13	11	2	0
0	0.8	1.3	0	15	16	0.1	3.5	2	0	71	23	22	0	1	17	1	-1	1	12	0	-9	-9	-9	2	0
0	0.6	2.8	0	15	12	0.1	3.5	2	0	71	23	21.5	0	1	30	1	0	1	14	0	-9	-9	-9	2	-1
0	0.5	4.3	0	15	16	0.3	4	2	0	68	23.9	21.6	0	1	38	1	1	1	14	0	-9	-9	-9	2	-1

EOF

CG-41341 MARCH 14 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.3	0.3	0	15	15	0.4	3.3	1	0	78	26	24	0	1	-15	0	0	0.7	8	0	3	98	1	3	1
0	0.9	0.9	0	15	15	0.3	3.3	1	0	78	26	23.9	0	1	-9	0	0	0.7	8	0	-9	-9	-9	3	1
0	0.3	1.3	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-5	0	0	0.7	8	0	-9	-9	-9	3	1
0	1	1.5	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	-3	0	0	0.7	8	0	-9	-9	-9	3	1
0	0.5	1.7	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	0	0	0	0.7	8	0	-9	-9	-9	3	1
0	0.1	2	0	15	15	0.3	3.3	1	0	78	26	23.8	0	1	3	0	0	0.7	8	0	-9	-9	-9	3	1
0	0.7	2.4	0	15	15	0.3	3.6	1	0	76	26	23.8	0	1	6	0	1	0.7	8	0	-9	-9	-9	3	1

EOF

CG-41341 MARCH 19 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
0	0.1	0.5	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-61	0	-1	0.2	15	0	-9	-9	-9	3	1
1	0.1	0.8	0	15	8	0.9	2.3	0	0	78	23.3	23.5	0	1	-58	0	0	0.2	15	0	2	100	3	3	1
0	0.8	0.1	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-64	0	1	0.2	15	0	-9	-9	-9	3	1
0	0.7	0.3	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-63	0	1	0.2	15	0	-9	-9	-9	3	1
0	0.8	0.6	0	15	8	0.9	2.3	0	0	78	23.3	23.5	-1	1	-60	0	1	0.2	15	0	-9	-9	-9	3	1
0	0.7	1	0	15	8	0.9	2.3	0	0	78	23.3	23.5	1	1	-56	0	-1	0.2	15	0	-9	-9	-9	3	1
0	0.1	1.2	0	15	7	0.9	2	0	0	78	23.3	23.5	1	1	-53	0	-1	0.2	15	0	-9	-9	-9	3	1
0	0.2	1.4	0	15	7	0.9	2	0	0	78	23.3	23.5	1	1	-51	0	-1	0.2	15	0	-9	-9	-9	3	1
0	0.3	1.9	0	15	7	0.9	2	0	0	78	23.3	23.5	-1	1	-46	0	1	0.2	15	0	-9	-9	-9	3	1
0	0.2	2.6	0	15	5	0.3	2.3	0	-1	78	23.3	23.5	1	1	-38	0	-1	0.2	15	0	-9	-9	-9	3	1
0	1	3.5	0	15	6	0.9	2	0	1	74	23.9	23.5	-1	1	-30	0	1	0.2	15	0	-9	-9	-9	3	1
0	0.9	3.8	0	15	6	0.9	2	0	1	74	23.9	23.5	-1	1	-25	0	0	0.2	15	0	-9	-9	-9	3	1
0	0.4	4	0	15	6	0.9	2	0	1	74	23.9	23.5	-1	1	-22	0	0	0.2	15	0	-9	-9	-9	3	1
0	0.7	4.4	0	15	6	0.9	2.3	0	1	74	23.9	23.5	-1	1	-18	0	0	0.2	15	0	-9	-9	-9	3	1
0	0.4	4.5	0	15	6	0.9	2.3	0	0	74	23.9	23.5	0	1	-17	0	0	0.2	15	0	-9	-9	-9	3	1
0	0.2	5.2	3	15	6	0.9	2.3	0	-1	74	24.4	23.5	1	1	-10	0	0	0.2	15	0	-9	-9	-9	3	1
0	0.7	5.5	3	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-7	0	0	0.2	15	0	-9	-9	-9	3	1
0	0.7	5.9	0	15	6	0.9	2.3	0	1	74	24.4	23.5	-1	1	-4	0	0	0.2	15	0	-9	-9	-9	3	1

EOF

CG-41341 MARCH 22 1990

DET	LATRNG	TOT	PRECIP	VIS	WDSP	CLDC	HS	WHCAPS	SWDIR	RELHM	AIRTP	WTTP	RELAZ	LEV	ELEV	MOONVIS	MOONRA	PHS	SPD	ALTTYPE	POS	LO	EXP	TYNO	SUBTY
1	0.1	4.1	0	15	7	0.3	3.9	0	1	61	22.2	22	-1	1	-39	0	1	0.2	10	0	4	99	1	2	-1
0	0.7	1.5	0	15	12	0.4	4.3	0	1	65	22.7	22.1	-1	1	-63	0	0	0.2	10	0	-9	-9	-9	2	-1
0	0.4	2.4	0	15	12	0.4	4.3	0	-1	65	22.7	22	1	1	-56	0	-1	0.2	10	0	-9	-9	-9	2	-1
0	0.6	3	0	15	14	0.1	3.9	0	1	61	22.2	21.9	-1	1	-50	0	1	0.2	10	0	-9	-9	-9	2	-1
0	0.4	4	0	15	7	0.3	3.9	0	0	61	22.2	22	0	1	-40	0	0	0.2	10	0	-9	-9	-9	2	-1
0	0.5	4.8	0	15	8	0.3	3.9	0	-1	60	21.6	21.8	1	1	-31	0	-1	0.2	10	0	-9	-9	-9	2	-1
0	0.8	5.6	0	15	8	0.3	3.9	0	-1	60	21.6	21.9	1	1	-22	0	-1	0.2	10	0	-9	-9	-9	2	-1

EOF